LIVING WITH A STAR

GEOSPACE

MISSION ASSURANCE REQUIREMENTS (MAR)

Effective Date: April 28, 2005

Expiration Date: April 28, 2010

Check the LWS Document Library at:

http://gdms.gsfc.nasa.gov/gdms/plsql/frontdoor

to verify that this is the correct version before use.

CHANGE RECORD PAGE (1 OF 1)

DOCUMENT TITLE: GEOSPACE Mission Assurance Requirements

DOCUMENT DATE: March 2005

ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Initial	4/05	All	Initial Baseline Release per CCR 462-10

Prepared by:

______________________________ ______________

Teresa James **Date**

Office of Systems Safety and Mission Assurance

Approved by:

______________________________ ______________

Robert Lebair **Date**

Geospace Mission Manager

Concurrence:

______________________________ ______________

Laurie Kleppin **Date**

LWS/SEC, Systems Assurance Manager

TABLE OF CONTENTS

Chapter 1.0 Overall Requirements

1.1 GENERAL

The purpose of this document is to concisely present the Safety and Mission Assurance (SMA) requirements necessary for the Geospace Missions. This document will present Safety and Mission Assurance (SMA) requirements at the Geospace Mission level and appendices to this document will be used to present any project specific requirements. It should be noted that when Geospace Project is referenced, it is referring to Johns Hopkins University (JHU)/Applied Physics Laboratory (APL) and when Geospace Program is referenced, it is referring to the NASA/Goddard Space Flight Center Living With a Star (LWS) Program office. The Missions under the LWS/Geospace Program are identified as follows:

1. <u>The Ionosphere-Thermosphere Storm Probes (ITSPs) Investigation</u> – The I-T Storm Probes are two spacecraft in nearly identical, 60º-inclination, and circular orbits at altitudes at a nominal altitude of 450km. This orbit permits the satellites to be close to the F-region peak altitude, to be at sufficiently low altitudes to permit in situ measurements of the neutral gas properties that couple with ionospheric plasma, and yet be high enough altitudes to be consistent with a mission lifetime of at least 3 years. Both spacecrafts are identically instrumented to understand the response of the upper atmosphere and ionosphere to solar and magnetospheric forcing and its coupling to the lower atmosphere. Separation of the spacecrafts ascending nodes by about 10º to 20º will make it possible to characterize I-T longitudinal behavior and coherence scales, to identify sources and sinks, resolve mid-latitude irregularities, and to understand transport mechanisms.

2. <u>Radiation Belt Storm Probes (RBSPs) Investigation</u> – The RBSP mission involves two identical spacecraft in low inclination, highly elliptical orbits. The inclination must be 18° geographic latitude or less, with a 12° or lower goal. Perigee is at 500km altitude with apogee at 30,600km, which corresponds to a geocentric radial distance of 5.8 Earth radii. The two spacecraft are placed in orbits with slightly different periods so that one spacecraft completes a “lap” with respect to the other every few months. The two spacecraft are launched together on a Delta II 2425-9.5 or similar launch vehicle directly into the target orbit. After deployment, each spin-stabilized spacecraft will precess its spin axis to the sun. The RBSP instrumentation provides measurements of radiation belt particles, electric and magnetic fields, ring current particles, and low energy plasma. Two spacecraft provide multipoint measurements to separate transport from local acceleration mechanisms and to distinguish temporal and spatial variations. The goal of the RBSP is to understand how dynamically-interacting electromagnetic fields accelerate plasmas to relativistic energies, thereby developing the capability to specify and predict changes to planetary radiation environments.

The SMA requirements for the Geospace Missions are structured to accept the increased risk that is inherent in a predominately non-redundant system. A strong parts and materials program, robust reliability and quality programs for hardware and software, and significant reliance on the test program will be key factors in balancing requirements against program cost and complexity constraints. The developer has responsibility and control over development of the deliverable hardware, the integration and test program, and delivery to the Geospace Project Office. The Geospace Project Office will monitor the developer’s activities to provide insight into their compliance with SMA requirements. Emphasis will be focused on those activities that contribute most to product reliability and integrity. The Geospace Project Office shall ensure the Mission Assurance Requirements are flowed down to all of their developers/ vendors who are producing hardware, software, and critical ground support equipment. The Geospace Program Office will provide insight and oversight of the Geospace Project's activities while managing all Geospace Missions.

It should be noted that "developer" as specified in this document applies to Observatory, Instrument and Instrument-Suite Suppliers. In addition, the developers shall flow down the applicable sections of this document to each of their contractors and their subcontractors.

The developer shall use this Mission Assurance Requirements (MAR) Document in developing their SMA approach, and realistically addressing the costs associated with these tasks. The quality program shall be modeled after ANSI/ASQ Q9001-2000, "Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation, and Servicing".

The developer is encouraged to make maximum use of existing practices and procedures in developing and implementing the safety and mission assurance program. The developer may offer an alternate method of meeting the intent of a requirement when such a method is better aligned with the manner in which the total work is to be accomplished, subject to approval by the Geospace Project Office and/or the Geospace Program Office. The developer shall describe the plans for maintaining adequate internal documentation for all safety, reliability and quality assurance activities and for providing the Geospace Project Office with essential deliverable documentation. Upon request, all developer documents utilized on Geospace Missions shall be available for Geospace Program Office review.

1.2 DESCRIPTION OF OVERALL REQUIREMENTS

This document presents a concise statement of the Geospace Mission SMA requirements. The developer shall plan and implement an organized SMA program for flight hardware, software and ground support equipment as defined in this MAR appropriate to the nature of the particular deliverable hardware or software to be delivered. The developer shall support and participate with the Geospace Project Office in validating and periodically reviewing the SMA program.

Managers of assurance activities shall have direct access to developer management independent of Project management, along with the functional freedom and authority to interact with all other elements of the Project. The developer shall direct issues requiring Project management attention through the Geospace Contracting Officer's Technical Representative (COTR) or Contractor Representative.

1.3 USE OF MULTI-MISSION OR PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE

When hardware that was designed, fabricated, or flown on a previous Project is considered to have demonstrated compliance with some or all of the requirements of this document such that certain tasks need not be repeated, the developer shall demonstrate how the hardware complies with requirements.

1.4 SURVEILLANCE OF THE DEVELOPER

The work activities, operations, and documentation performed by the developer or their suppliers are subject to evaluation, review, audit, and inspection by government-designated representatives from the Geospace Project Office, the Government Inspection Agency, or an independent assurance contractor. The Geospace Project Office will delegate in-plant responsibilities and authority to those organizations via a letter of delegation, letter of assignment, or task assignment.

The developer shall grant access for NASA and NASA/GSFC representatives to conduct an assessment or survey upon notice. The developer, upon request, shall provide government assurance representatives with documents, records, databases and equipment required to perform their assurance and safety activities. The developer shall also provide the government assurance representative(s) with an acceptable work area within developer facilities.

1.5 SAFETY AND MISSION ASSURANCE VERIFICATION

The Geospace Project Office shall submit their Quality Manual (see Data Item Description (DID) 1) for Geospace Program Office review and approval. The Geospace Program Systems Assurance Manager (SAM) will periodically validate the developers' overall SMA program to inform the Program office of potential problems or concerns. Developers shall submit their Quality Manual for Geospace Project Office review and approval with concurrence from the Geospace Program SAM.

Chapter 2.0 Quality Management System

2.1 QUALITY MANAGEMENT SYSTEM

Each developer shall define and implement a quality system based on ANSI/ISO/ASQ Q9001: 2000 or equivalent that properly encompasses Geospace flight hardware, software, and ground support equipment. Each developer's Quality Manual, as required by this standard, shall be provided to the APL Geospace Project Office for review.

2.2 SUPPLEMENTAL QUALITY MANAGEMENT SYSTEM REQUIREMENTS

The following requirements supplement ANSI/ISO/ASQ Q9001:2000:

2.2.1 Nonconformance Reporting and Corrective Action

Each developer shall have a system for identifying and reporting hardware and software nonconformances through a closed loop reporting system; ensuring that positive corrective action is implemented to preclude recurrence and verification of the adequacy of implemented corrective action by audit and test as appropriate. Each developer shall provide the Geospace Project with documentation describing how nonconforming material is designated, controlled, and segregated from normal production flow. The document shall describe in detail the approval authority for accepting the disposition with government concurrence, and how the documentation is controlled, i.e. Material Review Boards (MRB).

The Nonconformance Reporting and Corrective Action (NRCA) process shall include:

1. Nonconformance detection and reporting procedures;
2. Nonconformance tracking and management procedures;
3. Nonconformance impact assessment and corrective action procedures;
4. Interfaces to the Configuration Management process.

2.2.2 Material Review Board

Each developer shall notify the Geospace Project Manager, who in turn shall notify the Geospace Program Office of a non-conformance within 24 hours of the occurrence.

Each developer shall inform the Geospace Project Manager, who in turn shall notify the Geospace Program Office of MRB meeting schedules and agendas with sufficient advance notice (four hours minimum) to permit participation. Developers shall provide the Geospace Project access to their material discrepancy-reporting database. The developer shall document MRB decisions related to material dispositions and shall notify the Geospace Project Office of decisions within 3 working days. The Geospace Project Manager and the Geospace Program Office reserves disapproval rights on MRB decisions. The Geospace Project shall notify developers in writing within 7 working days of any disapproval or conditional approval.

2.2.3 Reporting of Failures

Each developer shall report hardware/software failures to the Geospace Project Manager, who in turn shall report to the Geospace Program Office beginning with the first "power on application" tests at the major system, subsystem, instrument, or spacecraft level of flight hardware/software; or the first operation of a mechanical item. Reporting shall continue through successful closure by the Failure Review Board (FRB).

Failures shall be reported to the Geospace Project Manager, who in turn shall report to the Geospace Program Office within 24 hours of the occurrence. Problem Failure Reports (DID # 2) documenting the failure and investigation shall be supplied to the Geospace Project Manager, who in turn shall supply this report to the Geospace Program Office within 3 business days of the occurrence. Monthly, each developer shall provide to the Geospace Project a list of all open failure reports and a separate list of the failure reports closed during the month. The Geospace Project Manager and the Geospace Program Office reserves disapproval rights on failure report dispositions prior to Observatory or Instrument Integration and Test (I&T). The Geospace Project shall notify developers in writing within 5 calendar days of receiving the failure disposition report, of any disapproval or conditional approval. The Geospace Project Manager and the Geospace Program Office reserves final approval of all failure report dispositions starting at the first instrument I&T with the spacecraft.

Each developer shall implement a process for Software NRCA that addresses reporting, analyzing, and correcting nonconformances throughout the development life cycle. Each developer's Quality Manual shall provide for a corrective action process that tracks every nonconformance to its final disposition. The NRCA process for a software product shall start no later than the establishment of a configuration management baseline that includes the product.

2.3 Control of Monitoring and Measuring Devices

The Developer's Testing and Calibration Laboratories shall be compliant with the requirements of ISO 17025 – General Requirements for the Competence of Testing and Calibration Laboratories.

2.4 Configuration Management

Each developer shall perform configuration management (CM) in support of the Geospace Project. Each developer shall document the CM process in a Configuration Management Plan (DID #3) submitted to the Geospace Project. The configuration of deliverable items shall be maintained throughout all phases of assembly and test. Configuration verification shall be performed and documented as assemblies are incorporated into higher-level assemblies and at major Project milestones (i.e. pre-environmental test, pre-ship, pre-launch, etc). The CM system shall have a change classification and impact assessment process that results in Class 1 changes being forwarded to the Geospace Program and Project for disposition and approval. Class 1 changes are defined as major changes that affect mission requirements, system safety, cost, schedule, and external interfaces. All other changes are considered to be Class 2 changes.

Any flight item that is found to be non-compliant with the requirements of the contract Statement Of Work (SOW) or the MAR and is not reworked to be compliant, or is not replaced with a compliant item, shall be dispositioned via a waiver. Waivers that affect mission requirements, system safety, cost, schedule, and external interfaces are to be processed as Class I. Software CM is further defined in Chapter 5 of this MAR.

2.5 GROUND SUPPORT EQUIPMENT

Mechanical and electrical Ground Support Equipment (GSE) and associated software that directly interfaces with flight deliverable items shall be subject to verification process prior to use with flight equipment. The verification process shall be documented and specifically address fitness for use, risk to flight hardware, safety, calibration control and configuration management. Problem reporting shall begin with the first use with deliverable flight items and shall continue for the duration of the Project.

2.6 REQUIREMENTS FLOW-DOWN

Each developer shall ensure flow-down of technical requirements to all suppliers and establish a process to verify compliance. Each developer's contracts review and purchasing processes shall indicate the process for documenting, communicating, and reviewing requirements with sub-tier suppliers to ensure requirements are met. The applicable sections in the Mission Assurance Requirements shall be flowed down to all institutions, domestic or foreign, providing hardware/software/ground system for the Geospace Missions, regardless of the funding source of the institution.

Chapter 3.0 System Safety

3.1 GENERAL

Each developer shall implement a system safety program in accordance with contractual and regulatory requirements. The system safety program shall be initiated in the concept phase of design and continue throughout all phases of the mission as defined by the requirements documents in this Chapter. Each developer shall implement a program that provides for early identification and control of hazards during design, fabrication, test transportation, and ground activities.

Each developer shall plan and implement a system safety program that accomplishes the following:

a. Identifies and controls hazards to personnel, facilities, support equipment, and the flight system during all stages of Project development. The Geospace Project Office shall address hazards in the flight hardware, associated software, ground support equipment, and support facilities;

b. Meets the system safety requirements of AFSPCMAN 91-710, “Range Safety User Requirements” and KNPR 8715.3 "KSC Safety Practices Procedural Requirements". Meets the baseline industrial safety requirements of the institution, AFSPCMAN 91-710, and any special contractually imposed mission-unique obligations.

Specific safety requirements include the following:

- If a system failure may lead to a catastrophic hazard, the system shall have three inhibits (dual fault tolerant). A Catastrophic hazard is defined as (1) A hazard that could result in a mishap causing fatal injury to personnel, and/or loss of one or more major elements of the flight vehicle or ground facility. (2) A condition that may cause death or permanently disabling injury, major system or facility destruction on the ground, or vehicle during the mission.
- If a system failure may lead to a critical hazard, the system shall have two inhibits (single fault tolerant). A Critical hazard is defined as a condition that may cause severe injury or occupational illness, or major property damage to facilities, systems, or flight hardware.
- Hazards which cannot be controlled by failure tolerance (e.g., structures, pressure vessels, etc.) are called "Design for Minimum Risk" areas of design and have separate, detailed safety requirements that they must meet. Hazard controls related to these areas are extremely critical and warrant careful attention to the details of verification of compliance on the part of the developer.

3.2 SYSTEM SAFETY REQUIREMENTS

Each developer shall implement a system safety program in accordance with NPR 8715.3 “NASA Safety Manual” and the requirements imposed by the GSFC Code 302 System Safety and Reliability Office (SSRO) and the appropriate launch service provider/launch range safety representative as defined below.

3.2.1 Safety Requirements Documentation

3.2.1.1 NASA Safety Requirements

- NPD 8710.2 "NASA Safety & Health Program Policy"
- NPR 8715.3 "NASA Safety Manual"
- NASA STD 8719.8 "Expendable Launch Vehicle Payload Safety Review Process Standard"
- NASA STD 8719.9, Standard for Lifting Devices and Equipment

3.2.1.2 GSFC Safety Requirements

All testing performed at GSFC will comply with the safety requirements contained in:

- 540-PG-8715.1.1 & 540-PG-8715.1.2, Mechanical Systems Division Safety Manual, Vol. I & II
- GPD 8715.1 Goddard Space Flight Center Safety Policy

3.2.1.3 ELV Eastern Test Range (ETR) or Western Test Range (WTR) Safety Requirements

- AFSPCMAN 91-710, "Range Safety User Requirements"
- KNPR 8715.3 "KSC Safety Practices Procedural Requirements".
- Facility-specific Safety Requirements, as applicable

3.2.1.4 Additional References

- NSI-AIAA S-080-1998, "Space Systems – Metallic Pressure Vessels, Pressurized Structures, and Pressure Components" – (supersedes MIL-STD-1522)
- ANSI-AIAA S-081-2000, "Space Systems – Composite Overwrapped Pressure Vessels (COPVs)" - (supersedes MIL-STD-1522)
- MIL-STD-1576, "Electroexplosive Subsystem Safety Requirements and Test Methods for Space Systems"
- MIL-STD-882, "Standard Practice for Systems Safety"
- 29 CFR 1910, "Occupational Safety and Health Standards"

3.3 SYSTEM SAFETY DELIVERABLES

The safety deliverables described in the following sections serve to demonstrate compliance with launch range safety requirements. All safety deliverables shall be sent directly by the spacecraft developer to the Geospace Project Office for review and approval by the Geospace Program Office and GSFC SSRO.

3.3.1 System Safety Program Plan

The spacecraft developer shall prepare a formal System Safety Program Plan (SSPP) (CDRL #4) intended to ensure that all Geospace safety requirements are achieved in an efficient manner. The plan shall describe the system by which hazards are identified, the procedures used to eliminate or effectively control them, and methods used to verify the controls. It shall include both management and technical approaches to reduce risk to an acceptable level for personnel, facilities and equipment throughout the system life cycle.

The approved plan will be submitted to the Geospace Project, the Geospace Program SAM and the GSFC SSRO for approval prior to submittal to the launch range. The SSPP provides a formal basis of understanding between the developer and the GSFC SSRO to document how the system safety program will be conducted to meet the range safety requirements, including general and specific provisions. The approved plan shall account for all contractually required tasks and responsibilities on an item-by-item basis, and will address the roles and responsibilities of each organization.

3.3.2 Safety Requirements Compliance Checklist

The developer shall demonstrate that the payload is in compliance with all safety requirements and any non-compliant areas have been identified. The developer shall document this in a Compliance Checklist (CDRL # 5). Safety compliance will be granted via GSFC Code 302 Safety Certification letter to the Geospace Project Manager, Geospace Program Manager and Geospace Program Systems Assurance Manager only after verification that all applicable safety requirements have been met.

3.3.3 Safety Analyses

The developer shall perform the following analyses:

3.3.3.1 Preliminary Hazard Analysis

The purpose of this task is to perform and document a Preliminary Hazard Analysis (PHA) to identify safety critical areas, to provide an initial assessment of hazards, and to identify recommended hazard controls and follow-on actions. The developer shall perform and document a PHA to obtain an initial risk assessment of a concept or system. Based on the best available data, including mishap data from similar systems and other lessons learned, hazards associated with the proposed design or function shall be evaluated for hazard severity, hazard probability, and operational constraint. Safety provisions and alternatives needed to eliminate hazards or reduce their associated risk to an acceptable level shall be included (CDRL # 6)

3.3.3.2 Operating and Support Hazard Analysis

The purpose of this task is to perform and document Operating and Support Hazard Analysis (O&SHA) to evaluate activities for hazards or risks introduced into the system during prelaunch processing and to evaluate adequacy of procedures used to eliminate, control, or abate identified hazards or risks

The developer shall perform an O&SHA to examine procedurally controlled activities at the launch site or processing facilities. The O&SHA identifies and evaluates hazards resulting from the implementation of operations or tasks performed by persons, considering the following criteria: the planned system configuration and/or state at each phase of activity; the facility interfaces; the planned environments; the supporting tools or other equipment, including software controlled automatic test equipment, specified for use; operational and/or task sequence, concurrent task effects and limitations; biotechnological factors, regulatory or contractually specified personnel safety and health requirements; and the potential for unplanned events including hazards introduced by human errors. The human shall be considered an element of the total system, receiving both inputs and initiating outputs during the conduct of this analysis. The results of the O&SHA shall be documented in the MSPSP.

3.3.3.3 Software Safety

Section 5.2.2 describes desired software safety activities to meet NASA HQ guidelines. Hazards caused by software will be identified as a part of the nominal hazard analysis process, and their controls will be verified prior to acceptance.

3.4 Safety Assessment Report

Each developer shall perform and document a comprehensive evaluation of the safety risk associated with their instrument or system. The Safety Assessment Report (SAR) (CDRL #7) is used to assist the Geospace spacecraft developer in preparing the Missile System Prelaunch Safety Package (MSPSP) for submittal to the launch range. This safety assessment shall identify all safety features of the hardware, software, and system design, as well as procedural related hazards present in the system. At a minimum, the SAR shall include:

a. Safety criteria and methodology used to classify and rank hazards

b. Results of hazard analyses and tests used to identify hazards in the system

c. Hazard reports documenting the results of the safety program efforts

d. List of hazardous materials generated or used in the system

e. Conclusion with a signed statement that all identified hazards have been eliminated or controlled to an acceptable level

f. Recommendations applicable to hazards at the interface of their system

3.5 MISSILE SYSTEM PRELAUNCH SAFETY PACKAGE

The spacecraft developer shall prepare and submit a Missile System Prelaunch Safety Package (MSPSP), (CDRL # 8) to the Geospace Program Office and the GSFC SSRO for review and approval before submittal to the launch range. Early in the project lifecycle, the developer will work with GSFC SSRO to tailor (as appropriate) safety requirements deemed not applicable to the payload, and then coordinate these with the launch range. Also early in the design phase and continuing throughout the development effort, the developer shall identify hazards associated with the flight system, ground support equipment, and their interfaces that affect personnel, launch vehicle hardware, or the spacecraft. The SARs from instrument and subsystem developers shall be used as inputs for the development of the MSPSP.

The MSPSP shall include, as a minimum, a detailed description of the payload design sufficient to support hazard analysis results, hazard analysis methodology, and other applicable safety related information. In addition to identifying hazards, the MSPSP shall also identify applicable hazard controls, and verifications methods for each hazard, and document them in Hazard Reports. The analysis shall be updated as the hardware progresses through the stages of design, fabrication, and test. A list of all hazardous/toxic materials and associated material safety data sheets shall be prepared and included in the final MSPSP, as well as a detailed description of the hazardous and safety critical operations associated with the payload. The safety assessment shall begin early in the program formulation process and continue throughout all phases of the mission lifecycle. The developer shall demonstrate compliance with these requirements and shall certify to GSFC SSRO and the launch range, through the MSPSP, that all safety requirements have been met.

3.6 Verification Tracking Log

The developer shall establish a "closed loop" process for tracking all hazards to acceptable closure through the use of a Verification Tracking Log (VTL), (CDRL #9). The VTL shall be delivered with the final MSPSP and updated regularly until all items are closed. Individual VTL items shall be closed with appropriate documentation verifying the stated hazard control has been implemented, and individual closures shall be complete prior to first operational use/restraint.

3.7 Ground Operations Procedures

The developer shall submit, in accordance with the contract schedule, all ground operations procedures (CDRL # 10) to be used at NASA facilities or the launch site. All hazardous operations, as well as the procedures to control them shall be identified and highlighted. All launch site procedures shall comply with the launch site and NASA safety regulations. The Geospace Program SAM and the GSFC SSRO will review and approve all hazardous procedures before submittal to the launch range.

3.8 Safety Noncompliance/Waiver Requests

When a specific safety requirement cannot be met, the spacecraft developer shall submit an associated safety noncompliance/waiver request (CDRL # 11). The request shall identify the hazard and show the rationale for approval.

The following definitions apply to the safety variance approval policy:

a. Variance: Documented and approved permission to perform some act or operation contrary to established requirements.

b. Deviation: A documented variance that authorizes departure from a particular safety requirement that does not strictly apply or where the intent of the requirement is being met through alternate means that provide an equivalent level of safety with no additional risk. The OSHA requirements (1910 29 CFR) term for deviation is alternate or supplemental standard only when it applies to OSHA requirements.

c. Waiver: A variance that authorizes departure from a specific safety requirement where a special level of risk has been documented and accepted.

All requests for variance will be accompanied by documentation as to why the requirement can not be met, the risks involved, alternative means to reduce the hazard or risk, the duration of the variance, and comments from any affected employees or their representatives (if the variance affects personal safety).

3.9 Support for Safety Working Group Meetings

Technical support shall be provided to the Project for Safety Working Group (SWG) meetings, Technical Interface Meetings (TIM), and technical reviews, when necessary. The SWG will meet as necessary to review procedures and analyses that contain or examine safety critical functions or as convened by the Project Safety Manager (PSM) to discuss any situations that may arise with respect to overall project safety.

3.10 Orbital Debris Assessment

An Orbital Debris Assessment (or the information required to produce the assessment) consistent with NPD 8710.3B, Policy for Limiting Orbital Debris Generation and NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris shall be provided (CDRL # 12).

3.11 Launch Site Safety Support

The spacecraft developer shall consider manpower requirements necessary for safety support of hazardous operations at the launch site. Range safety is not responsible for project safety support at the launch ranges.

3.12 MISHAP REPORTING AND INVESTIGATION

Any mishaps, incidents, and hazards, and close calls shall in accordance with NPR 8621.1 form. Mishaps at GSFC facilities shall be reported in accordance with NPR 8621.1, “Reporting of Mishaps, Incidents, Hazards, and Close Calls”.

Chapter 4.0 Reliability

4.1 RELIABILITY REQUIREMENTS

Early in the design process each developer shall identify specific reliability concerns and the steps being taken to mitigate them. Reliability analyses of the design shall be conducted in accordance with the following sections. These analyses shall be reviewed with the Geospace Project as they are developed and iterated, and reported in detail at the formal design reviews.

The Reliability program shall:

a. Use Probabilistic Risk Assessments (PRA) and Fault Tree Analyses (FTA) to assess, manage, and quantitatively assess the need to reduce program risk;

b. Demonstrate that redundant functions, including alternative paths and work-arounds, are independent to the extent practicable;

c. Demonstrate that stress applied to parts is not excessive;

d. Identify single point failure items, their effect on the attainment of mission objectives, and possible safety degradation;

e. Show that the reliability design meets mission design life requirements and is consistent among the systems, subsystems, and components;

f. Identify limited-life items and ensure that special precautions are taken to conserve their useful life for on-orbit operations;

g. Select significant engineering parameters for the performance of trend analysis to identify performance trends during pre-launch activities;

h. Ensure that the design permits easy replacement of parts and components and that redundant paths are easily monitored.

4.2 RELIABILITY ANALYSES

Each developer shall perform reliability analyses concurrently with the design so that identified problem areas can be addressed and corrective action taken (if required) in a timely manner.

4.2.1 Failure Modes and Effects Analysis and Critical Items List

Each developer shall perform a Failure Modes and Effects Analysis (FMEA) (CDRL #13) early in the design phase to identify system design problems. As additional design information becomes available each developer shall refine the FMEA. Failure modes shall be assessed at the component interface level. Each failure mode shall be assessed for the effect at that level of analysis, the next higher level and upward. The failure mode shall be assigned a severity category based on the most severe effect caused by a failure. Mission phases (e.g., launch, deployment, on-orbit operation, and retrieval) shall be addressed in the analysis.

Severity categories shall be determined in accordance with Table 4-1:

TABLE 4-1 SEVERITY CATEGORIES

Category	Severity	Description
1	Catastrophic	Failure modes that could result in serious injury, loss of life (flight or ground personnel), or loss of launch vehicle.
1R		Failure modes of identical or equivalent redundant hardware items that, if all failed, could result in category 1 effects.
1S		Failure in a safety or hazard monitoring system that could cause the system to fail to detect a hazardous condition or fail to operate during such condition and lead to Severity Category 1 consequences.
2	Critical	Failure modes that could result in loss of one or more mission objectives as defined by the Geospace Project office with concurrence of Geospace Program SAM.
2R		Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed.
3	Significant	Failure modes that could cause degradation to mission objectives.
4	Minor	Failure modes that could result in insignificant or no loss to mission objectives

FMEA analysis procedures and documentation shall be performed in accordance with documented procedures. Failure modes resulting in Severity Categories 1, 1R, 1S or 2 shall be analyzed at a greater depth, to single parts if necessary, to identify the cause of failure.

Results of the FMEA shall be used to evaluate the design relative to requirements (e.g., no single instrument failure will prevent removal of power from the instrument). Identified discrepancies shall be evaluated by management and design groups for assessment of the need for corrective action. The FMEA shall analyze redundancies to ensure that redundant paths are isolated or protected such that any single failure that causes the loss of a functional path will not affect the other functional path(s) or the capability to switch operation to that redundant path.

For highly redundant spacecraft, all failure modes that are assigned to Severity Categories 1, 1R, 1S, and 2, shall be itemized on a Critical Items List (CIL) and maintained with the FMEA report. For spacecraft that are primarily single string, failures of major component or subsystem level functions that are assigned to Severity Categories 1, 1R, 1S, and 2 shall be itemized on a Critical Items List (CIL) (CDRL #13) and maintained with the FMEA report. Rationale for retaining the items will be included on the CIL. The FMEA and CIL shall be submitted to the Geospace Project in accordance with the contractual deliverable list. Results of the FMEA and the CIL shall be presented at all design reviews starting with the Preliminary Design Review. The presentations shall include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

4.2.1.1 Probabilistic Risk Assessment and Fault Tree Analysis

Each developer shall use Probabilistic Risk Assessment (PRA) (CDRL #14) and Fault Tree Analysis (FTA) (CDRL #15) as part of the Project's risk management and reliability programs. Each developer shall include specific results in their Preliminary Design Review (PDR), Critical Design Review (CDR) and post-CDR reviews. The PRA and FTA shall be submitted to the Geospace Project in accordance with the contractual deliverable list.

Each developer shall perform FTAs that address both mission failures and degraded modes of operation. Beginning with each undesired state (mission failure or degraded mission), the fault tree shall be expanded to include all credible combinations of events, faults and environments that could lead to that undesired state. Component hardware/software failures, external hardware/software failures, and human factors shall be considered in the analysis.

4.2.1.2 Probabilistic Risk Assessment (PRA)

Each developer shall perform PRAs that include an analysis of the probability (or frequency) of occurrence of a consequence of interest, and the magnitude of that consequence, including assessment and display of uncertainties. The PRA shall be implemented as part of the systems engineering process, based on comprehensive systems analysis with analytical support, and repeated periodically as the design matures and new data become available.

4.2.1.3 Parts Stress Analyses

Each developer shall perform stress analyses (CDRL #16) on Electrical, Electronic, and Electromechanical (EEE) parts and devices, as applied in circuits within each component for conformance with the derating policy of the GSFC PPL-21 (Preferred Parts List). The analyses shall be performed at the most stressful part-level parameter values that can result from the specified performance and environmental requirements on the assembly or component. The analyses shall be performed in close coordination with the packaging reviews and shall require input data for component-level design reviews. The analyses shall be documented, and justification shall be included for all applications that do not meet the derating criteria.

4.2.1.4 Worst Case Analyses

Each developer shall perform worst-case parameter analyses (CDRL #17) on performance critical or functional critical components for which excessive operating variations could compromise mission performance. Adequate margins in electronic circuits, optics, electromechanical devices, or other mechanical items (mechanisms) can be verified by analysis, testing or both. When verification by analysis is used, the analyses shall consider all parameters at worst-case limits and worst-case environmental conditions for the parameter or operation being evaluated. Similarly, when verification by testing is used, the testing shall be conducted to provide as direct a measure as possible of the critical performance or function while the element is subjected to worst-case parameter variations. Elements that may warrant worst case analysis may include: control loops that require adequate phase and gain margin to operate properly, sensitive analog circuitry, power supply or switching circuitry, motor and actuator systems, electro-mechanical elements that require torque margin to operate over life and environmental variations.

4.2.1.5 Reliability Assessments and Predictions

Each developer shall perform comparative numerical reliability assessments and/or reliability predictions to:

a. Evaluate alternative design concepts, redundancy and cross-strapping approaches, and part substitutions;
b. Identify the elements of the design which are the greatest detractors of system reliability;
c. Identify those potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations;
d. Assist in evaluating the ability of the design to achieve the mission life requirement and other reliability goals and requirements as applicable;
e. Evaluate the impact of proposed engineering change and waiver requests on reliability.

Each developer shall describe in their assessments the level of detail of a model suitable for performing the intended functions enumerated above. The assessments and updates (CDRL #18) shall be submitted to the Geospace Project for information in accordance with the contractual deliverable list. The results of any reliability assessment shall be reported at PDR and CDR. The presentations shall include comments on how the analysis was used to perform design trade-offs or how the results were taken into consideration when making design or risk management decisions.

4.3 RELIABILITY ANALYSIS OF TEST DATA

Each developer shall fully utilize test information during the normal test program to assess flight equipment reliability performance and identify potential or existing problem areas.

4.3.1 Trend Analyses

Each developer shall perform trend analyses (CDRL #19) to the component level to track measurable parameters that relate to performance stability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring shall be accomplished within the normal test framework (i.e., during functional tests, environmental tests, etc). Each developer shall establish a system for recording and analyzing the parameters as well as any changes from the first observed value even if the levels are within specified limits. A list of parameters to be monitored and the trend analysis reports shall be available to the Geospace Project and/or Geospace Program Office upon request. Trend analysis data shall be reviewed with the mission operational personnel prior to launch, and the mission operational personnel shall continue recording trends throughout mission life for early detection of possible mission failure tendencies.

4.3.2 Analysis of Test Results

Each developer shall analyze test information, trend data, and failure investigations to evaluate reliability implications. Identified problem areas shall be documented and directed to the attention of developer management for action. This information shall be included in the developer's monthly status reports to the Geospace Project.

4.4 Limited-Life Items

Each developer shall identify and manage limited-life items. Limited-life items include all hardware that is subject to degradation because of age, operating time, or cycles such that their expected useful life is less than twice the required life when fabrication, test, storage, and mission operation are combined. The developer shall maintain a list of limited-life items (CDRL #20), which shall include the following data elements: item, expected life, required life, duty cycle, rationale for selection and effect on mission parameters. An item's useful life period begins with either (1) its fabrication or (2) installation into flight hardware, as appropriate, and ends when the orbital mission is completed.

The list of limited-life items should include selected structures, thermal control surfaces, instrument sensors, and electromechanical mechanisms. Atomic oxygen, solar radiation, shelf-life, extreme temperatures, thermal cycling, wear and fatigue should be used to identify limited-life thermal control surfaces and structure items. Mechanisms such as batteries, compressors, seals, bearings, valves, tape recorders, momentum wheels, gyros, actuators, and scan devices should be included when aging, wear, fatigue and lubricant degradation limit their life. Records shall be maintained that allow evaluation of the cumulative stress (time and/or cycles) for limited-life items, starting when useful life is initiated and indicating the Project activity that stresses the items. The proposed use of an item whose expected life is less than its mission design life shall be considered a non-compliance and must be approved by the Geospace Project by means of a waiver with concurrence from the Geospace Program SAM.

Chapter 5.0 Software Assurance Requirements

5.1 GENERAL

For the purposes of Chapter 5, all references to the developer shall include the prime software developer, as well as any subcontractors tasked in the development process.

5.2 SOFTWARE ASSURANCE

Software Assurance is the planned and systematic set of activities that ensures that software lifecycle processes and products conform to requirements, standards, and procedures (Institute of Electrical and Electronics Engineers (IEEE) 610.12). As such, software assurance comprises a set of disciplines that strive to improve the overall quality of the product/software while employing risk mitigation techniques. For NASA, these disciplines include Software Quality, Software Safety, Software Reliability, Verification and Verification (V&V), and Independent Verification and Validation (IV&V).

The developer's Software Assurance program shall address software assurance disciplines and functions for all flight and ground system software. The software assurance program shall apply to software and firmware developed under this contract, including Government off-the-shelf (GOTS) software, modified off-the-shelf (MOTS) software, and commercial off-the-shelf (COTS) software when included in a NASA system.

The developer shall identify a person responsible for managing the Software Assurance Program (e.g., a software assurance manager). The developer shall prepare and maintain a Software Assurance Plan (**CDRL #21**) that meets the intent of Institute of Electrical and Electronics Engineers (IEEE) Standard 730, "Software Quality Assurance Plans" and NASA-STD-8739.8, NASA Software Assurance Standard.

The developer shall also plan and document software roles and responsibilities, software development processes and procedures, software reviews, software tools, resources, schedules, and deliverables throughout the development life cycle in a Software Management Plan (CDRL 22). The developer shall document and maintain under configuration control all software requirements in a Software Requirements Specification.

5.2.1 Software Quality

The developer shall implement a Software Quality program to assure the quality of the software products and software processes. The function of software quality assurance assures that the standards, processes, and procedures are appropriate for the project and correctly implemented, while software quality control assures adherence to those software requirements, plans, procedures and standards. Software quality personnel shall plan and conduct process and product assurance activities throughout the development life cycle. At a minimum, these activities shall include assessments of plans, procedures, requirements, design, code, test, configuration management, risk management, and verification and validation.

5.2.2 Software Safety

Software safety is a systematic approach to identifying, analyzing, tracking, mitigating and controlling software hazards and hazardous functions (data and commands) to ensure safer software operation within a system.

The developer shall conduct a Software Safety program that is integrated with the overall software assurance and systems safety program and is compliant with the software safety requirements of NASA-STD-8719.13. The developer shall document their approach to the Software Safety program in the System Safety Program Plan (see Section 3.3 or the Software

Management Plan (CDRL #22) as appropriate. The developer shall ensure that software safety requirements are clearly identified, documented, traced and controlled throughout the lifecycle. In cases, where the developer cannot meet a software safety requirement and/or feels that it is not in the best interest of the project to implement, the developer shall document these items in a deviation/waiver package. The developer shall furnish this deviation/waiver package to the customer for review/disposition.

5.2.3 Software Reliability

The developer shall conduct a Software Reliability program for incorporating and measuring reliability in the products produced by each process of the life cycle. Software reliability optimizes the software through emphasis on requiring and building in software error prevention, fault detection, isolation, and recovery.

The developer shall document their Software Reliability program in the Software Management Plan. Items to be specifically addressed in the plan shall include the activities to be undertaken to achieve the software reliability requirements, as well as the activities to be undertaken to demonstrate that the software reliability requirements have been verified. Measurements for evaluating reliability (e.g., defect density and mean-time-to-failure) shall be documented.

5.2.4 Verification and Validation

The developer shall plan and implement a Verification and Validation (V&V) program (including documented test plans, procedures, and test reports) to ensure that software being developed or maintained satisfies functional, performance, and other requirements at each stage of the development process and that each phase of the development process yields the right product. To assist in the verification and validation of software requirements, the developer shall develop and maintain under configuration control a Software Requirements Verification Matrix. This matrix shall document the flow-down of each requirement to the test case and test method used to verify compliance and the test results. The matrix shall be made available to the project upon request.

5.2.5 Independent Verification and Validation

The developer shall provide all information required for the NASA Independent Verification and Validation (IV&V) effort to the Geospace Project and Program for submittal to NASA IV&V Facility personnel. This includes, but is not limited to, access to all software reviews and reports, contractor plans and procedures, software code, software design documentation, and software problem reporting data. Wherever possible, the developer shall permit electronic access to the required information or furnish soft copies of requested information to NASA IV&V personnel.

The developer shall review and assess all NASA IV&V findings and recommendations. The developer shall forward their assessment of these findings and recommendations to the Geospace Project and Program, which in turn will forward this assessment to NASA IV&V personnel accordingly. The developer shall take necessary corrective action based upon their assessment and notify NASA IV&V personnel, via the Geospace Project and Program, of this corrective action. The developer shall also notify NASA IV&V personnel, via the Geospace Project and Program, of those instances where they chose not to take corrective action. A developer Point of Contact shall be assigned and available to NASA IV&V personnel, as required, for questions, clarification, and status meetings.

5.3 REVIEWS

5.3.1 Software Reviews

The developer shall conduct the following formal software reviews with Geospace Project and Program personnel in attendance and/or on the review team:

1. Software Requirements Review (SRR).
2. Preliminary Design Review (PDR).
3. Critical Design Review (CDR).
4. Test Readiness Review (TRR).
5. Acceptance Review (AR).

If software is addressed as part of the formal system-level reviews (e.g., SRR, PDR, or CDR), the developer shall adhere to the review criteria identified in Chapter 6.

The developer shall record and maintain minutes and action items from each review. The developer shall respond to Request for Actions (RFAs) and any action items assigned by the review panel and/or the project as a result of each review and provide a status of all action items and RFAs at subsequent software or system-level reviews.

5.3.2 Engineering Peer Reviews

The developer shall implement a program of engineering peer reviews (e.g., requirements or design walkthroughs) throughout the software development lifecycle to identify and resolve concerns prior to formal system/subsystem level reviews. Peer review teams shall be comprised of technical experts with significant practical experience relevant to the technology and requirements of the software to be reviewed. These reviews shall be commensurate with the scope, complexity, and acceptable risk of the software system/product.

Action items or Requests for Action (RFAs) from engineering peer reviews shall be recorded, maintained, and tracked throughout the development lifecycle.

5.4 Software Configuration Management

The developer shall develop and implement a Software Configuration Management (SCM) system that provides baseline management and control of software requirements, design, source code, data, and documentation. The developer shall document the SCM system, and associated tools, in the developer's Configuration Management Plan (CDRL #5) or the Software Management Plan. The plan shall address software configuration identification, configuration control, configuration status accounting, and configuration audits and reviews.

5.5 Software Problem Reporting And Corrective Action

The developer shall document and implement a process for Software Problem Reporting and Corrective Action that addresses reporting, analyzing, and tracking software nonconformances throughout the development lifecycle.

5.6 GFE, Existing And Purchased Software

If the developer will be provided software or firmware as GFE, or will use existing or purchased software or COTS, the developer shall ensure that the software meets the functional, performance and interface requirements placed upon it. The developer shall ensure that the software meets applicable standards, including those for design, code and documentation.

5.7 Software Assurance Status reporting

As part of the Project Monthly Status Reports, the developer shall include the following software assurance highlights:

1. Assurance accomplishments and resulting software assurance metrics for activities such as, but not limited to, inspection and test, reviews, contractor/subcontractor surveys, and audits.
2. Significant problems or issues that could affect cost, schedule and/or performance.
3. Plans for upcoming software assurance activities.

Chapter 6.0 Technical Review Requirements

6.1 General Requirements

Each developer shall provide support for a formal review program chaired by a NASA selected review chair that ensures that the Geospace Mission Assurance review program:

1. Assures that the spacecraft, instrument(s), Instrument Suite and supporting designs are consistent with the Geospace Project Mission Requirements Document;
2. Assures that the characteristics of the systems are carefully examined to develop the best approach consistent with existing constraints and available resources;
3. Provides a means of periodic evaluation of the hardware, software, and ground support development;
4. Assures that end-item deliverables (systems and subsystems) meet the Geospace project requirements for performance.

Each developer shall provide the following formal system level reviews (Hardware and Software):

- System Requirement Review;
- Preliminary Design Review;
- Critical Design Review;
- Pre-Environmental Review;
- Pre-Ship Review;

Each developer shall support the series of comprehensive system-level design reviews that are conducted by the GSFC Systems Review Office (SRO). The reviews cover all aspects of flight and ground hardware, software, and operations for which the developer has responsibility. For each specified system-level review conducted by the GSFC SRO, each developer shall:

a. Develop and organize material for oral presentation to the Geospace government review team. Copies of the “final” presentation material will be provided to the Geospace Project 5 days prior to the meeting;

b. Support splinter review meetings resulting from the major review;

c. Produce written responses to action items resulting from the review;

d. Summarize, as appropriate, the results of the developer reviews at the component and subsystem level.

6.2 Phase B Reviews

The System Review Team (SRT) will include personnel experienced in subsystem design, systems engineering and integration, testing, and all other applicable disciplines. The GSFC SRO will chair these reviews. The review chairs, in concert with the Geospace Project Office appoint independent key technical experts as review team members. Phase B formally begins with the signed contract agreement for the mission and ends with formal confirmation for the mission by NASA Headquarters following a Confirmation Review (CR). During Phase B the mission team shall hold a System Requirements Review (SRR) and Preliminary Design Review (PDR) prior to the CR.

System Requirement Review (SRR) – this review is keyed to the end of the definition study phase and shall evaluate the design approaches, hardware/software tradeoffs, software requirements and the operational concepts. See CDRL #23

Preliminary Design Review (PDR) – This review occurs early in the design phase prior to manufacture of engineering hardware and the detail design of associated software. Where applicable, the developer shall include the results of test bedding, breadboard testing, and software prototyping. Long-lead procurements shall be discussed. Efforts to retire identified risk items shall be discussed. See CDRL #24

6.3 Phase C/D Reviews

Critical Design Review (CDR) – This review occurs after the design has been completed but prior to the start of manufacturing flight components or the coding of software. Each developer shall emphasize implementations of design approaches as well as test plans for flight systems including the results of engineering model testing. See CDRL #25

Mission Operations Review (MOR) – This mission-oriented review will normally take place prior to significant integration of the flight Observatory system and prior to the Observatory Pre-Environmental Review. The purpose is to review the status of the system components, including the ground system and its operational interfaces with the flight system. See CDRL #26

Pre-Environmental Review (PER) – This review occurs prior to the start of environmental testing of the flight instrument. Each developer shall present the readiness of the flight hardware and software, and facilities for system level test and evaluate the environmental test plans. See CDRL #27.

Pre-Ship Review (PSR) – This review shall take place prior to shipment of the instrument-suite to the observatory. Each developer shall present evidence to show that testing has been completed with no unacceptable open issues and will evaluate the readiness of the hardware and software for flight. Each developer shall address the testing on flight hardware and software, verification and documentation of the hardware and software configuration, identification of outstanding safety risks, disposition of waivers/deviations/open issues, compatibility of spacecraft and ground support equipment, and orbital operations plans. See CDRL #28.

Flight Operations Review (FOR) - This review emphasizes the final orbital operations plans as well as the compatibility of the flight components with ground support equipment and the ground network, including summary results of the network compatibility tests. The FOR will be held near the completion of pre-launch testing between the flight segment and the ground system. Each developer shall present their plans for final end-to-end testing and simulations. The results of previous testing shall be included (i.e. discrepancy summary, network compatibility assessment, training status, etc.). The final launch, orbital operations, and checkout plans shall be presented. See CDRL #29.

Launch Readiness Review (LRR): This purpose of this review is to assess the overall readiness of the total system to support the flight objectives of the mission. The LRR will be held two to three days before scheduled launch at the launch site. Each developer shall present a summary of all the activities since the Pre-Shipment Review and the Flight Operations Readiness review, the closure of any actions from those reviews and a summation of all the testing and launch operations planning and rehearsals to the present. Any open items and residual risks shall be presented. See CDRL #30.

Ground System Reviews – Ground systems are subject to the same review requirements as flight systems.

6.4 Peer Reviews

The developer shall implement a program of engineering peer reviews (e.g., requirements or design walkthroughs) throughout the software/hardware development lifecycle to identify and resolve concerns prior to formal system/subsystem level reviews. Peer review teams shall be comprised of technical experts with significant practical experience relevant to the technology and requirements of the software to be reviewed. These reviews shall be commensurate with the scope, complexity, and acceptable risk of the software/hardware system/product. To promote continuity of the whole review program, each developer shall notify the Geospace Project of the peer review schedule to allow participation by the GSFC Systems Review Office and the Geospace Program technical experts.

Action items or Requests for Action (RFAs) from engineering peer reviews shall be recorded, maintained, and tracked throughout the development lifecycle.

6.5 Review Action Item Tracking

Each developer shall implement a system for tracking the status and resolution of Action Items initiated during peer and formal reviews, and the status of these Action Items shall be reported at the formal reviews. Action Items shall be assigned unique control numbers that identify the item under review and the review type. The numbering/tracking system shall be capable of differentiating Action Items of any specific system review from all other system reviews.

Chapter 7.0 Design Verification Requirements

7.1 General Requirements

Each developer shall conduct a system performance verification program covering the component through Instrument or Observatory levels. Each developer shall document the overall verification plan (See CDRL #31), implementation, and results to ensure that the spacecraft and instruments meet the specified mission requirements, and to provide traceability from mission requirements through launch and on-orbit capability. The program shall consist of a series of functional demonstrations, analytical investigations, physical property measurements, and environmental tests that simulate the environments encountered during handling and transportation, pre-launch, launch, and on-orbit. Each developer shall maintain as-run verification procedures, including all test and analysis data.

All flight hardware and software shall undergo qualification to demonstrate compliance with the requirements of this section. In addition, all other hardware (flight follow-on, spare and re-flight) shall undergo acceptance in accordance with the requirements of this section.

The Verification Program shall begin with functional testing at the component level of assembly. It shall continue through functional and environmental testing at the component, subsystem, instrument, spacecraft and observatory levels of assembly, supported by appropriate analysis. The program shall conclude with end-to-end testing of the entire operational hardware/software system at the observatory level including the instruments, the ground control center, and the appropriate network elements.

The GEVS-SE for STS & ELV Payloads, Subsystems, and Components shall be used to develop each instrument/instrument-suite and Spacecraft/Observatory level verification programs. The GEVS-SE document is available at http://arioch.gsfc.nasa.gov/302/verifhp.htm.

7.2 Requirements Verification Matrix

Each developer shall provide adequate documentation to demonstrate compliance with all performance requirements identified in the contract SOW. Each developer shall have a Requirements Verification Matrix (CDRL #32) or equivalent system that shows the flow-down of all requirements and the methods of verification. The Requirements Verification Matrix and supporting documentation shall provide the following information:

- Systems Performance Validation Plan flow-down;
- Basis for verification method (test, analysis, similarity, heritage, etc.);
- Dates accomplished with name and signature of person performing the action;
- Dates verified with name and signature of person verifying performance;
- Definition of specific environments for each requirement;
- Tracking of requirements verified against those planned;
- Detailed supporting documentation of compliance with each requirement.

7.3 Environmental Test Program

Each developer shall conduct an environmental test program for flight hardware sufficient to demonstrate design qualification, acceptance, and to test for workmanship. Spacecraft developer should provide environmental test levels to the contractors, instrument and instrument-suite developers. Functional testing shall be performed before, during, and after environmental tests, as appropriate. Each developer's environmental test plans shall define the specific parameters associated with the planned environmental tests. Each developer shall consider payload peculiarities and interactions with the launch vehicle in defining these environmental parameters. These special interactions include subjects like resonance de-tuning, EMI/EMC effects, pyrotechnic firing disturbances, etc. as applicable.

As an adjunct to the Environmental Test program, an environmental test matrix (ETM) shall be prepared that summarizes all tests that will be performed on each component, each subsystem or instrument and the Observatories. The purpose is to provide a ready reference to the contents of the test program in order to prevent the deletion of a portion thereof without an alternative means of accomplishing the objectives. The matrix shall be prepared in conjunction with the overall verification plan and shall be updated as changes occur.

Each developer shall establish environmental test levels to encompass predictions based on launch vehicle information, ground test environments, and worst case on operational conditions.

Prototype and protoflight hardware shall undergo appropriate qualification tests to demonstrate compliance with the design requirements. Flight, flight spare, follow-on, and re-flight hardware shall undergo flight-like acceptance test levels to verify acceptable assembly workmanship.

The following environmental exposures are required as a baseline for Observatories and Instruments:

<u>Components:</u>

Sine Vibration, Random Vibration, Strength, EMI/EMC, Thermal Vacuum/Thermal Balance, Mass Properties, and Deployment shall be performed. Comprehensive Performance Tests (CPTs) shall be part of the verification program at these levels of assembly.

<u>Observatory and Instrument Levels:</u>

Strength (static or quasi-static), Low level (Pogo) Sine Vibration, Random Vibration, Acoustics, Mechanical Shock, EMI/EMC, Thermal Vacuum/Thermal Balance, Mass Properties, and Deployment shall be performed.

Repeated functional tests should be used to demonstrate the growing maturity of the instruments or spacecraft subsystems, perform trending analysis, and to baseline performance status before each environmental test. CPT demonstrations shall be performed to verify full mission hardware compliance, compatibility, and operability; and to perform trending analysis.

7.4 End-To-End Test

Prior to the PSR of the Geospace Observatory, each developer shall perform and/or participate in an end-to-end compatibility test to demonstrate the ground system capability to communicate with the observatory (up-link and down-link) via the ground to space network. Simulated normal orbital mission scenarios encompassing launch, systems turn-on, housekeeping, command/control, and stabilization/pointing shall be demonstrated, including the collecting, processing, and archiving of science data. Observatory immunity to erroneous commands, autonomous safe-hold, and simulated anomaly recovery operations shall also be demonstrated.

7.5 Demonstration of Failure-free Operation

At the conclusion of the developers' verification program prior to delivery to the observatory, the Geospace sub-systems, instrument and instrument-suites shall have demonstrated a period of 200 hours of consecutive failure-free operation, 100 hours of which are consecutive failure-free operation in its simulated mission orbital environment (thermal vacuum). Prior to shipment to the launch site, the Geospace Observatory (instrument-suite/spacecraft), shall have demonstrated a period of 500 hours of consecutive failure-free operation, 250 hours of which are consecutive failure-free operation in its simulated mission orbital environment (thermal vacuum). The demonstration may be performed at the subsystem level when the time period of demonstration cannot be practically accomplished at the system level of assembly. Major changes during or after the failure-free period will invalidate any previous demonstration. Note: These hours do not have to be consecutively powered, the instrument suite is allowed to power off and on to achieve this total.

Chapter 8.0 Workmanship Standards and Processes

8.1 General Requirements

Each developer shall plan and implement a Workmanship Program to assure that all electronic packaging technologies, processes, and workmanship activities selected and applied meet mission objectives for quality and reliability.

8.2 Applicable Documents***

Conformal Coating and Staking: NASA-STD-8739.1, Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies;

Soldering – Flight, Surface Mount Technology: NASA-STD-8739.2, Surface Mount Technology;

Soldering – Flight, Manual (hand): NASA-STD-8739.3, Soldered Electrical Connections;

Soldering – Ground Systems: IPC/EIA J-STD-001C, Requirements for Soldered Electrical and Electronic Assemblies;

Electronic Assemblies – Ground Systems: IPC-A-610C, Acceptability of Electronic Assemblies;

Crimping, Wiring, and Harnessing: NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring;

Fiber Optics: NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation;

Electrostatic Discharge Control (ESD): ANSI/ESD S20.20-1999 ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)

Printed Wiring Board (PWB) Design:

- IPC 2221 Generic Standard on Printed Wiring Board Design and IPC 2222 Sectional Design Standard for Rigid Organic Printed Boards
- IPC-2223, Sectional Design Standard for Flexible Printed Boards;

Printed Wiring Board Manufacture:

- IPC A-600, Acceptability of Printed Boards
- IPC-6011, Generic Performance Specification for Printed Boards
- IPC-6012, Qualification and Performance Specification for Rigid Printed Boards
  - Flight Applications – IPC-6012B Qualification and Performance Specification for Rigid Printed Boards all flight boards shall be compliance with the Performance Specification Sheet for Space and Military Avionics (SMA specification sheet) <u>In the event of a conflict between the Design and Manufacture Specifications, the SMA specification</u> shall take precedence
  - IPC-6013, Qualification and Performance Specification for Flexible Printed Boards.

***Current status and/or any application notes for these standards can be obtained at URL http://standards.nasa.gov

8.3 DESIGN

8.3.1 Printed Wiring Boards

The Printed Wiring Board (PWB) manufacturing and acceptance requirements identified in this chapter are based on using PWBs designed in accordance with the PWB design standards referenced above or equivalent (MIL-PRF-55110). Space flight PWB designs shall not include features that prevent the finished boards from complying with the Class 3 Requirements of the appropriate manufacturing standard (e.g., specified plating thicknesses, internal annular ring dimensions, etc.).

8.3.2 Assemblies

The design considerations in the NASA workmanship standards listed above should be incorporated.

8.3.3 Ground Systems That Interface With Space Flight Hardware

Ground system assemblies that interface directly with space flight hardware or will reside with the space flight hardware in environmental chambers or other test facilities that simulate a space flight environment (e.g., connectors, test cables, etc.) shall be designed, documented, reviewed and implemented using processes that ensure the safety and integrity of the flight hardware. This process shall include a peer review process, a verification process including testing prior to use with flight hardware. GSE designs shall be maintained under configuration management prior to test and validation.

NOTE: Printed Wiring Boards that interface directly with flight hardware are to be built IAW IPC 6012b Performance Specification Sheet for Space and Military.

8.4 WORKMANSHIP REQUIREMENTS

8.4.1 Training and Certification

All personnel working on deliverable hardware shall be certified as having completed the required training, appropriate to their involvement, as defined in the above standards.

8.4.2 Flight and Harsh Environment Ground Systems Workmanship

8.4.2.1 Printed Wiring Boards

Printed Wiring Boards (PWBs) shall be manufactured in accordance with the Class 3 Requirements in the above referenced PWB manufacturing standards or equivalent (MIL-PRF-55110). Each developer shall provide printed wiring board (PWB) coupons (CDRL #33) to the Geospace Program SAM, or to a GSFC-approved laboratory for evaluation. PWB coupon approval shall be obtained prior to population of flight PWBs. Each developer may have the coupons evaluated at an alternate laboratory if written approval is obtained from the Geospace Program SAM in advance. If an approved alternate laboratory is used, delivery of the test reports to the Geospace Program SAM is required.

8.4.2.2 Assemblies

Assemblies shall be fabricated using the appropriate workmanship standards listed above (i.e., NASA-STD-8739.3 for hand soldering; NASA-STD-8739.4 for crimping/cabling; NASA-STD-8739.1 Polymeric Applications; ANSI/ESD S20.20-1999 for ESD Control; NASA-STD-8739.2, Surface Mount Technology; (NASA-STD-8739.5 for fiber optic termination and installation; etc.).

8.4.3 Ground Systems (non-flight) Workmanship

8.4.3.1 Printed Wiring Boards

PWBs which do not interface directly with flight hardware shall be manufactured in accordance with the Class 2 Requirements.

8.4.3.2 Assemblies

Assemblies shall be fabricated using the Class 2 Requirements of J-STD-001C and IPC-A-610C, and ANSI/ESD S20.20-1999. If any conflicts between J-STD-001C and IPC-A-610C are encountered, the requirements in J-STD-001C shall take precedence.

8.5 Documentation

Each developer shall document the procedures and processes that will be used to implement the above referenced workmanship, design, and ESD control standards including any procedures or process requirements referenced-in via those standards.

Each developer may propose alternate standards. Proposals for use of alternate standards must be accompanied by objective data that documents mission safety or reliability will not be compromised. Each developer's use of alternate standards is limited to the Geospace hardware and only after they have been reviewed and approved by the Geospace Project and Program offices.

8.6 New or Advanced Packaging Technologies

New and/or existing advanced packaging technologies (e.g., multi-chip modules (MCMs), stacked memories, chip on board, ball grid array (BGA), etc. shall be reviewed, approved by the Project Parts Control Board and included in the Parts Identification List (PIL) and the Project Approved Parts List (PAPL).

8.7 Hardware Handling

The handling of flight hardware shall be performed by trained personnel in accordance with approved procedures that address cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., antistatic film materials), and purging. Procedures for the control of contamination shall be implemented in all phases of assembly and test. All personnel working on flight hardware shall be certified as having completed the required certifications prior to handling any flight hardware. This includes, but is not limited to, the aforementioned workmanship, design and ESD awareness courses.

8.8 Electrostatic Discharge Control (ESD) Requirements

Each developer shall document and implement an ESD Control Program Plan (CDRL # 42) in accordance with ANSI/ESD S20.20-1999 suitable to protect the most sensitive components used in the Project. At a minimum, the ESD Control Program shall address training, protected work area procedures and verification schedules, packaging, handling of Electrostatic Discharge Sensitive (ESDS) items, facility maintenance, storage, and shipping.

All personnel who manufacture, inspect, test, otherwise process electronic flight hardware, or require unescorted access into ESD protected areas shall be certified as having completed the required training, appropriate to their involvement, as defined in ANSI/ESD S20.20-1999 prior to handling any electronic hardware.

Electronic flight hardware shall be manufactured, inspected, tested, or otherwise processed only at designated ESD protective work areas. These work areas shall be verified on a regular schedule as identified in the developer's ESD Control Program.

Electronic flight hardware shall be properly packaged in ESD protective packaging at all times when not actively being manufactured, inspected, tested, or otherwise processed.

Chapter 9.0 Parts Requirements

9.1 General

Each developer, contractor and each subcontractor (hereon referred to as “the developer”) shall plan and implement an EEE Parts Control Program to assure that all parts selected for use in flight hardware meet mission objectives for quality and reliability. The program shall be in place to effectively support the design and selection processes for the duration of the contract. The developer shall control the selection, application, evaluation, and acceptance of all parts through a Parts Control Board (PCB), or equivalent developer documented process of parts control and shall be approved by Geospace Project with concurrence by the Geospace Program SAM.

All parts shall be selected and processed in accordance with GSFC *EEE Parts Selection, Screening, Qualification and Derating* (EEE-INST-002) for part quality level 2. Exceptions for use of a lesser grade part with additional testing shall only be made on a case by case basis when a level 2 part is not available. Such exceptions require approved by the PCB.

The developer shall prepare a Parts, Materials and Processes Control Plan (PMPCP) (CDRL #34) describing the approach and methodology for implementing their Parts and Materials Control Program. The PMPCP shall also define the developer’s criteria for parts and materials selection and approval based on the guidelines of sections 9.0 and 10.0. The Parts Control Board and Materials Control Board are separate boards. The approach and methodology for implementing their Parts and Materials Control Program shall be addressed in the same PMPCP.

The developer shall designate one key individual to be their Project Parts Engineer (PPE). The PPE shall have the prime responsibility for management of their EEE parts control program. This individual shall have direct, independent and unimpeded access to the Geospace Project and Program PPEs and Parts Control Board. The PPE shall work with design engineers, radiation engineers, reliability engineers and the Geospace Project and Program PPEs to perform part selection and control.

Tasks typically performed by the prime contractor PPE and each subcontractor PPE shall include but are not limited to the following:

1. Work with Geospace Project and Program PPEs team to perform parts control.

2. Provide PCB agenda, prepare Parts Lists and provide supporting part information for parts evaluation and approval by the PCB.

3. Coordinate Parts Control Board meetings, maintain minutes, develop and maintain the Project Parts Identification Lists, develop the Project Approved Parts List (PAPL) and the As Built Parts List (ABPL).

4. Perform Customer Source Inspections (CSI) and audits at supplier’s facilities as necessary or as directed by the PCB.

5. Prepare part procurement, screening, qualification, and modification specifications, as required.

6. Diposition/track part nonconformance’s and part failure investigations.

7. Track and report impact of Alerts and Advisories on flight hardware.

9.2 Parts Control Board (PCB)

The developer shall establish a Parts Control Board (PCB) or a similar documented system to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the contract. The PCB shall be responsible for the review and approval of all EEE parts, for conformance to established criteria of section 9.4 (including radiation effects), and for developing and maintaining a Program Approved Parts List (CDRL #35). In addition, the PCB is responsible for providing assistance in all parts activities such as part failure investigations, disposition of part non-conformances, and part problem resolutions. PCB operating procedures shall be included as part of the PMPCP.

9.2.1 PCB Responsibilities

The PCB responsibility shall include but not limited to the following:

- Evaluation of EEE parts for conformance to established criteria and inclusion in the PAPL,
- Develop and maintain a Program Approved Parts List (PAPL)
- Review and approve EEE part derating as necessary for unique applications,
- Define testing requirements,
- Review unique applications (including radiation effects),
- Track part failure investigations and non-conformances.

If there are any parts issues that cannot be resolved at the PCB level, the issues shall be elevated to the Geospace Program Office at NASA for resolution.

9.2.2 PCB Meetings and Notification

PCB meetings shall be convened on a regular basis or as needed. The PCB meeting may be conducted via phone conversation when needed on a case-by-case basis. The Geospace Program Parts Engineer shall be a permanent voting member of PCB meetings. Developer PPE shall maintain meeting minutes or records to document all decisions made and a copy provided to Geospace Program Office within five business days of convening the meeting. Geospace Program Office will retain the right to overturn decisions involving non-conformances within ten days after receipt of meeting minutes.
The developer PPE shall notify attendees at least five (5) working days in advance of all upcoming meetings. Notification shall as a minimum, include a proposed agenda and Parts Identification List of candidate parts (see section 9.6 of this document).

9.2.3 PCB Membership

As a minimum, the PCB membership shall consist of the Developer's Product Assurance Manager, developer PPE, the Geospace Project Parts Engineer (PPE), the Geospace Program Parts Engineer and the Geospace Project Radiation Engineer (PRE) when required. The developer PPE and Geospace Project PPE shall participate in all PCB meetings. The Geospace Program PPE may attend as necessary. The developer PPE, the Geospace Project and Program PPEs and Geospace Project PRE shall be permanent working and voting members of the PCB. The developer PPE shall assure that the appropriate individuals with engineering knowledge and skills are represented as necessary at meetings, such as part commodity specialists, Radiation Engineers or the appropriate subsystem design engineer.

If there are any parts issues that cannot be resolved at the PCB level, the issues shall be elevated to the Geospace Project Manager for disposition.

9.3 Part Selection and Processing

9.3.1 General

All part commodities identified in EEE-INST-002 are considered EEE parts and shall be subjected to the requirements set forth in this section. EEE Parts types that do not fall in to any of the categories covered in EEE-INST-002 shall be reviewed on a case-by- case basis using the closest NASA, DSCC or government controlled specification. In the event a suitable government baseline specification does not exist, the developer PPE shall consult the Geospace Project PPE and identify the best available industry standard for that particular commodity, and develop appropriate procurement, screening and qualification specification.

9.3.2 Parts Selection

Parts shall be selected from the GSFC EEE Parts Selection, Screening, Qualification and Derating document (EEE-INST-002), or the NASA Parts Selection List (NPSL) for quality level 2 or better. Exceptions for use of a lower grade shall only be made on a case by case basis when a level 2 part is unavailable, and such exceptions require approved by PCB. The use of a lower grade part requires additional testing to be performed in accordance with EEE-INST-002 to upgrade the part to level 2.

EEE-INST-002 contains value added testing for a number of parts listed in the NPSL. These tests include PIND testing for all EEE devices, surge current testing for tantalum capacitors and dielectric screening for several types of ceramic capacitors. These and any other value added tests listed in EEE-INST-002 shall be performed to enhance the reliability of parts. PCB approval is required if there is any deviation from any screening or qualification tests as specified in EEE-INST-002.

9.3.3 Radiation Requirements for Part Selection

All parts shall be selected to perform their function in their intended application in the predicted radiation environment including the applicable Radiation Design Margin (RDM). The radiation environment causes the following three main degradation effects that must be accounted for all active parts selection:

- **Total Ionizing Dose (TID)**, including Enhanced Low Dose Rate (ELDR) effects. Parts shall be selected to ensure their adequate performance in the application up to a dose of 2x the expected mission dose.
- **Single-Event Effects (SEE),** Parts must be assessed for the potential of Single Event Upset (SEU) or Single Event Transient (SET), which requires analysis of the circuit application on a case-by-case basis. Parts susceptible to Single Event Latch up (SEL) should be avoided. If performance demands the use of an SEL susceptible part, measures shall be implemented to ensure that SEL induced damage (both prompt and latent) are mitigated and that the spacecraft performance is not compromised. These measures must be approved by the contractor Radiation Engineer (RE) and PPE, along with Geospace Project Radiation Engineer (PRE), the Geospace Project PPE, and the Geospace Program PPE before the part can be added to the PAPL.
- **Displacement Damage,** Parts shall be able to withstand the displacement damage due to high energy protons, to twice the fluence expected in the predicted Geospace environment. This effect can cause significant damage in optical devices.

These effects and others may require individual part application analysis to be performed as necessary by the PRE. The developer shall document the radiation analysis of each part as applicable.

9.3.4 Custom or Advanced Technology Devices.

Devices such as custom hybrid microcircuits, detectors, Application Specific Integrated Circuits (ASICs), and Multi Chip Modules (MCMs) shall also be subject to parts control and include a design review appropriate for the individual technology. The design review shall include element evaluation to assure each element's reliability, (review should include such items as burn-in, voltage conditioning, sample size, element derating, etc.), device construction and assembly process, including materials evaluation (for such items as contamination concerns, metals whisker concerns, and adequate material thermal matching; (Materials specialists may be consulted as necessary). A Customer Source Inspection may be required.
A procurement specification may be required for parts in this category based on the recommendation of the PPE. These specifications shall fully describe the item being procured and shall include physical, mechanical, environmental, electrical test requirements, and quality assurance provisions necessary to control manufacture and acceptance. Screening requirements designated for the part can be included in the procurement specification. Test conditions, burn-in circuits, failure criteria, and lot rejection criteria will be included. For lot acceptance or rejection, the Percentage of Defectives Allowable (PDA) in a screened lot shall be in accordance with that prescribed in the closest military part specification and/or GSFC EEE-INST-002.

9.3.5 Plastic Encapsulated Microcircuits (PEMs)

The use of Plastic Encapsulated Microcircuits is discouraged. However, when use of PEMs is necessary to achieve unique performance requirements that can not be achieved by using hermetic high reliability microcircuits, plastic encapsulated parts, must meet the requirements of EEE-INST-002. The PCB shall review the procurement specification, application of part, and storage processes for plastic encapsulated parts to assure that all aspects of EEE-INST-002 have been met.

9.3.6 Verification Testing

Re-performance of screening tests, which were performed by the manufacturer or authorized test house as required by the military or procurement specification, is not required unless deemed necessary as indicated by failure history, GIDEP Alerts, age or other reliability concerns. If required, testing shall be performed in accordance with GSFC EEE-INST-002 or as determined by the PCB.

9.3.7 Parts Approved on Prior Programs

Parts previously approved by NASA for other projects via prior PCB activity or a Nonstandard Parts Approval Request (NSPAR) shall not be granted "Grandfather approval" on GEOSPACE. However, existing approval packages may be brought to the PCB as an aid to present candidate parts for approval. (Preparation of NSPARs is not a requirement for GEOSPACE). Such candidate parts shall be evaluated by the PCB for compliance to current Program requirements by determining that:

1. No changes have been made to the previously approved NSPAR, Source Control Drawing (SCD) or vendor list.

2. All stipulations cited in the previous NSPAR approval have been implemented on the current flight lot, including performance of any additional testing.

3. The previous program's parts quality level is identical to the current program.

4. No new information has become available which would preclude the use of the previously approved part in a high reliability space flight application.

9.3.8 Parts Used in Off-the-Shelf Assemblies

Units or assemblies that are purchased as "off-the-shelf" hardware items shall be subjected to an evaluation of the parts used within them. The parts shall be evaluated for screening compliance to EEE-INST-002, established reliability level, and include a radiation analysis. Units may be required to undergo modification for use of higher reliability parts or Radiation hardened parts. All parts shall be subject to PMCB approval. Modifications such as additional shielding for radiation effectiveness or replacing radiation soft parts for radiation hardened parts may be required and shall be subject to RE approval.

9.4 Part Analysis

9.4.1 Destructive Physical Analysis

A sample of each lot date code of microcircuits, hybrid microcircuits, and semiconductor devices may be subjected to a Destructive Physical Analysis (DPA) based on PMPCB recommendation. All other parts may require a sample DPA if it is deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. DPA tests, procedures, sample size and criteria shall be as specified in GSFC specification S-311-M-70, *Destructive Physical Analysis*. Contractor's procedures for DPA may be used in place of S-311-M-70 and shall be submitted with the PMPCP for concurrence prior to use. The PMPCB on a case-by-case basis shall consider variation to the DPA sample size requirements, due to part complexity, availability or cost.

9.4.2 Failed EEE Parts

A EEE part failure is defined as a failure for which the part itself is the intrinsic cause, which occurs while the part is operating within its specification limits. Emphasis shall be placed upon detection, analysis, and feedback of failure data during unit level testing. The developer shall have a method in place to report all EEE component failures during EEE part screening and qualification and that occur during qualification and acceptance testing of flight hardware, beginning with the first application of power at the subassembly level continuing through, unit, subsystem, and system levels. The failure reporting plan shall include identification of failed parts, notification within an approved time of failure, retrieval of failed/overstressed parts, part failure analysis and documentation of all pertinent information related to each failure. The failure reporting plan shall be documented and presented to the PCB and the Geospace Project and Program Offices for review and approval.

9.4.3 Failure Analysis

When a component part Failure Analysis (FA) is necessary to support a Failure Review Board, the developer shall prepare a part Failure Analysis Report. The Contractor PPE shall submit the completed report to the PCB for review and approval in order to assure proper documentation is presented for the FRB. The failure report form shall as a minimum, provide the following information:

- The failed part's identity (part name, part number, reference designator, manufacturer, manufacturing lot / date code, and part serial number if applicable), and symptoms by which the failure was identified (the conditions observed as opposed to those expected).
- The name of the unit or subsystem on which the failure occurred, date of failure, the test phase, and the environment in which the test was being conducted.
- An indication of whether the failure of the part or item in question constitutes a primary or a secondary (collateral) failure (caused by another failure in the circuit and not a failure on its own merit.)
- The results of the failure analyses conducted and the nature of the rework/retest/corrective action taken in response.

The completed failure report shall include copies of any supporting photographs, X-rays, metallurgical data, microprobe or spectrographic data, Scanning Electronic Microscope (SEM) photographs, pertinent variables (electrical and radiation) data, etc. Radiation data shall be submitted where it is deemed pertinent to the failure mechanism.

9.5 Additional Requirements

9.5.1 Parts Age Control

Parts taken from user inventory older than 5 years do not require re-screen, provided they have been properly stored. Proper storage means maintaining the parts within their rated temperature range and protected from conditions that create electrostatic damage or contaminants that may affect their functionality (e.g., corrosive atmospheres that damage the plating on the leads or terminations). Storage areas shall be inspected and electrostatic discharge (ESD) certified for proper equipment and handling procedures in accordance with ANSI/ESD-S20.20, Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosives Devices). Parts over 10 years old from the date of manufacture to the date of procurement shall not be procured.

9.5.2 Derating

All EEE parts shall be used in accordance with the derating guidelines of GSFC EEE-INST-002. The developer's derating policy may be used in place of the GSFC guidelines and shall be submitted with the developer PMPCP for approval.

9.5.3 Alerts

The developer shall be responsible for the review and disposition of all GIDEP Alerts on parts proposed for flight use. In addition, any NASA Alerts and Advisories provided to the developer by the Geospace Program Office shall be reviewed and dispositional. Alert applicability, impact, and corrective actions shall be continuously documented and reported to the Geospace Project and Program Offices. The review process shall continue from delivery up to launch.

9.5.4 Prohibited Metals

Pure tin plating shall not be used in the construction and surface finish of EEE parts proposed for space hardware. Only alloys containing less than 97% tin are acceptable.

The use of pure cadmium or zinc is prohibited in the construction and surface finish of space hardware. All cadmium alloys or zinc alloys (e.g. brass) must be completely over plated with an approved metal. The Geospace Project and Program Offices shall be consulted as necessary.

9.6 Parts Lists

The developer shall develop and maintain a PAPL and a PIL for the duration of the project. The Contractor shall submit the PAPL to GSFC. Parts must be approved for listing on the PAPL before initiation of procurement activity. Long Lead items shall be identified on the PIL and have conditional approval from the PCB before procurement. All submissions to the GEOSPACE Project shall include a computer compatible form (Microsoft Excel, Microsoft Access, etc. Consult GSFC LPPE for acceptable format).

9.6.1 Parts Identification List (PIL)

The PIL shall list all parts proposed for use in flight hardware. The PIL is prepared from design team inputs or subcontractor inputs, to be used for presenting and tracking candidate parts to the PMCB. The PIL shall include as a minimum the following information: Item number, Generic Part Number, Procurement Part number, Spacecraft Name, Instrument Name, Description, Package: Case Style and Number of pins, Manufacturer, CAGE Code, Distributor, Additional Testing Required, Long Lead items Conditional Approval, Quantity needed, Quantity Procured, PCB Comments, Approval Date Radition Data Source: SEE; Radiation Hardness Evaluation: TID, Krads; Radiation Hardness Evaluation: SEL, MeV; Radiation Hardness Evaluation: SEU, MeV; Radiation Hardness Evaluation: Displacement Damage; Radiation Data Source: TID (See CDRL #36).

9.6.2 Program Approved Parts List (PAPL)

The PAPL shall be the only listing of approved parts for flight hardware, and shall be the combined listing of all parts submitted through Parts Identification Lists that are approved by the PCB, plus approval status and disposition notes. Only parts that have been evaluated and approved by the PCB shall be listed in the PAPL. The PCB shall assure standardization of parts listed in the PIL across various systems and subsystems. (See CDRL #35)

9.6.3 As-Built Parts List (ABPL)

An As-Built Parts List (ABPL) shall also be prepared and submitted to the GEOSPACE project by the Contractor PPE. The ABPL is generally a final compilation of all parts as installed in flight equipment, with additional “as-installed” part information such as manufacturer name, CAGE code, Lot-Date Code, part serial number (if applicable). Provisions shall be in place to find quantity used and provide traceability to box or board location through build paperwork. The manufacturer's plant specific CAGE code is preferred, but if unknown, the supplier's general CAGE code is sufficient. (See CDRL #37)

9.7 Data Requirements

9.7.1 General

Attributes summary data shall be kept available to the Geospace Project and Program Offices for all testing performed. Variable data (read and record) shall be recorded for initial, interim and final electrical test points and shall be kept available to the Geospace Project and Program Offices.

For flight lots with samples subjected to Radiation Lot Acceptance Testing (RLAT), the radiation report that identifies parameter degradation behavior shall be provided to the PCB, and variables data acquired during radiation testing shall be kept available to the Geospace Project and Program Offices.

9.7.2 Retention of Data, Part Test Samples and Removed Parts

All developers shall have a method in place for retention of data generated for parts tested and used in flight hardware. The data shall be kept on file in order to facilitate future risk assessment and technical evaluation, as needed. In addition, the contractor shall retain all part functional failures, all destructive and non-flight non-destructive test samples, which could be used for future validation of parts for performance under certain conditions not previously accounted for. These devices shall be kept until launch. PIND test failures may be submitted for DPA, or radiation testing, but are not recommended for use in engineering models. Data shall be retained for the useful life of the spacecraft, unless otherwise permitted by the PCB. All historical quality records and data required to support these records shall be retained for a period of 5 years and shall be provided to the Geospace Project and Program Offices upon request.

Chapter 10 Materials, Processes and Lubrication Requirements

10.1 GENERAL REQUIREMENTS

Each developer shall implement a comprehensive Materials and Processes Control Program as part of the PMPCP (CDRL #34) beginning at the design stage of the hardware. The program shall help ensure the success and safety of the mission by the appropriate selection, processing, inspection, and testing of the materials, processing and lubricants employed to meet the operational requirements for Geospace Missions. Approval is required for each material, lubrication usage, and associated manufacturing processes prior to their use in space-flight hardware. Materials selection shall be in accordance with the specific Project performance requirements and as defined below.

The developer shall designate one key individual to be their Materials Assurance Engineer (MAE). The MAE shall have the prime responsibility for management of their materials and processes control program. This individual shall have direct, independent and unimpeded access to the Geospace Project and Program MAEs and Materials Control Board. The developer MAE shall work with design engineers, radiation engineers, reliability engineers and the Geospace Project and Program MAEs to perform materials selection and control.

10.2 Materials Control Board (MCB)

The developer shall establish a Materials Control Board (MCB) or a similar documented system to facilitate the management, selection, standardization, and control of materials and processes, and associated documentation for the duration of the contract. The MCB shall be responsible for the review and approval of all materials and processes. The contractor shall be responsible for developing and maintaining a Materials Identification List (CDRL #38). In addition, the MCB is responsible for providing assistance in all material procedures such as material failures, disposition of non-conformances, and problem resolutions. MCB operating procedures shall be included as part of the PMPCP.

10.2.1 MCB Responsibilities

The MCB responsibility shall include but not limited to the following:

- Evaluation of materials for conformance to established criteria and inclusion in the MIL
- Develop and maintain an As Built Materials List (ABML)
- Review and approve materials as necessary for unique applications,
- Define testing requirements,
- Track material investigations and non-conformances.

10.2.2 MCB Meetings and Notification

MCB meetings shall be convened on a regular basis or as needed. The MCB meeting may be conducted via phone conversation when needed on a case-by-case basis. The developer MAE shall maintain meeting minutes or records to document all decisions made and a copy provided to GSFC within five business days of convening the meeting. Geospace Program Office will retain the right to overturn decisions involving non-conformances within ten days after receipt of meeting minutes.

The developer MAE shall notify attendees at least five (5) working days in advance of all upcoming meetings. Notification shall as a minimum, include a proposed agenda and Materials Identification List of candidate materials.

10.2.3 MCB Membership

As a minimum, the MCB membership shall consist of the Developer's Product Assurance Manager, developer MAE, and GSFC MAE. The Geospace Program System Assurance Manager (SAM) (or designee) may attend as necessary. The developer MAE and Geospace Project and Program MAEs shall be permanent working and voting members of the MCB. The developer MAE shall assure that the appropriate individuals with engineering knowledge and skills are represented as necessary at meetings.

If there are any materials issues that cannot be resolved at the MCB level, the issues shall be elevated to the Geospace Project Manager for disposition.

10.3 MATERIALS SELECTION REQUIREMENTS

In order to anticipate and minimize materials problems during space hardware development and operation, the developer shall, when selecting materials and lubricants, consider potential problem areas such as radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, toxicity, flammability and fracture toughness, as well as the properties required by each material usage or application.

10.3.1 Materials Identification List (MIL)

Each developer shall maintain Materials Identification Lists (MIL) (CDRL #38) of all materials planned for use in flight hardware, regardless of their approval status. The initial MILs and subsequent updates shall be submitted to the Geospace Project Office in accordance with the contract delivery requirements. An As-Built Materials List (ABML) (CDRL #39) shall also be prepared and submitted to the Geospace Project Office in accordance with the contract delivery requirements. The ABML is generally the final MIL with additional as-built information such as materials manufacturers.

The MILs shall include information for Polymeric Materials and Composites Usage, Inorganic Materials and Composites Usage, Lubrication Usage, and Material Process Utilization. Reference lists are provided in this document as a guide for all developer's (Figures 10-3 through 10-6). The MIL can be submitted as one list as long as it contains all the appropriate information referenced in the attached figures. These lists shall be reviewed and approved by the Geospace Project Materials Assurance Engineer (MAE).

10.3.2 Compliant Materials

Each developer shall use compliant materials in the fabrication of flight hardware to the extent practicable.

In order to be compliant, a material must be used in a conventional application and meet the following applicable selection criteria:

Hazardous materials requirements, including flammability, toxicity and compatibility as specified in AFSPC 910, and NASA-STD-6001;

- Vacuum Outgassing requirements as defined in paragraph 10.3.3;
- Stress corrosion cracking requirements as defined in MSFC- STD-3029.

10.3.3 Vacuum Outgassing

Material vacuum outgassing shall be determined in accordance with ASTM E-595. In general, a material is qualified on a product-by-product basis. However, the Geospace Project Office may require lot testing of any material for which lot variation is suspected. In such cases, material approval is contingent upon lot testing. Only materials that have a total mass loss (TML) less than 1.00% and a collected volatile condensable mass (CVCM) less than 0.10% shall be approved for use in a vacuum environment. A waiver shall be submitted to the Geospace Project Office for planned materials to be used, which do not meet the CVCM and/or TML requirement

10.3.4 Non-compliant Materials

A material that does not meet the requirements of the applicable selection criteria above (see 10.2.2), or meets the requirements above but is used in an unconventional application, shall be considered to be a non-compliant material. The proposed use of a non-compliant material requires a waiver to be submitted to the Geospace Project Office. This waiver can take the form of Materials Usage Agreement (Figure 10-1) and/or a Stress Corrosion Evaluation Form (Figure 10-2). If a developer prefers, they can use their own equivalent form for proposed usage of a non-compliant material.

10.3.4.1 Materials Used in "Off-the-Shelf-Hardware

"Off-the-shelf hardware" for which a detailed materials list is not available and where the included materials cannot be easily identified and/or changed shall be treated as non-compliant. The developer shall submit a waiver to the Geospace Project Office defining what measures will be used to ensure that all materials in the hardware are acceptable for use. Such measures might include any one, or a combination, of the following: hermetic sealing, vacuum bake-out, material changes for known non-compliant materials, etc. When a vacuum bake-out is the selected method, it shall incorporate a quartz crystal microbalance (QCM) and cold finger to enable a determination of the duration and effectiveness of the bake-out as well as compliance with the satellite contamination plan and error budget.

10.3.5 Conventional Applications (Definition)

Conventional applications or usage of materials is the use of compliant materials in a manner for which there is extensive satisfactory aerospace heritage.

10.3.6 Non-conventional Applications (Definition)

The proposed use of a compliant material for an application for which there is limited satisfactory aerospace usage shall be considered a non-conventional application. In that case, the material usage will be verified for the desired application on the basis of test, similarity, analyses, inspection, existing data, or a combination of those methods.

10.3.7 Polymeric Materials

Each developer shall include polymeric materials and composites on the MIL. Material acceptability shall be determined on the basis of flammability, toxicity, vacuum outgassing and all other materials properties relative to the application requirements and usage environment.

10.3.8 Shelf-Life-Controlled Materials

Polymeric materials that have a limited shelf life shall be controlled by a process that identifies the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf life and expiration date. Materials such as o-rings, rubber seals, tape, uncured polymers, lubricated bearings and paints shall be included. The use of materials with expired date code requires that the developer demonstrate by means of appropriate tests that the properties of the materials have not been compromised for their intended use; such materials shall be approved by the Geospace Project Office by means of a waiver. When a limited-life piece part is installed in a subassembly, the subassembly item shall be included in the Limited-Life Items List.

10.3.9 Inorganic Materials

Each developer shall include inorganic materials and composites on the MIL. In addition, each developer may be requested to submit supporting applications data. The criteria specified in MSFC- STD-3029 shall be used to determine that metallic materials meet the stress corrosion cracking (SCC) criteria. A wavier shall be submitted to the Geospace Project Office for each material usage that does not comply with the MSFC- STD-3029 SCC requirements (Reference Figure 10-1 and 10-2 as a guide.

10.3.9.1 Fasteners

Each developer shall comply with the procurement documentation and test requirements for flight hardware and critical ground support equipment fasteners contained in 541-PG-8072.1.2, Goddard Space Flight Center Fastener Integrity Requirements (formerly known as GSFC S-313-100). Material test reports or equivalent certification for fastener lots shall be submitted for information.

Fasteners made of plain carbon or low alloy steel shall be protected from corrosion. When plating is specified, it shall be compatible with the space environment. On steels harder than RC 33, plating shall be applied by a process that is not embrittling to the steel.

10.3.10 Lubrication

Each developer shall prepare and document a lubrication usage list as part of the MIL. In addition, each developer may be requested to submit supporting applications data.

Lubricants shall be selected for use with materials on the basis of valid test data and analysis results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination effects.

All lubricated mechanisms shall be qualified by life testing or analysis in accordance with the life test plan or heritage of an identical mechanism used in identical applications.

10.4 Process Selection Requirements

Each developer shall prepare and document a material process utilization list as part of the MIL. A copy of any process shall be submitted for review upon request. Manufacturing processes (e.g., lubrication, heat treatment, welding, chemical or metallic coatings) shall be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

10.5 Procurement Requirements

10.5.1 Purchased Raw Materials

Raw materials purchased by each developer shall be accompanied by the results of nondestructive, chemical and physical tests, or a Certificate of Compliance.

10.5.2 Raw Materials Used in Purchased Products

Each developer shall require that the supplier meet the requirements of 10.5.1 and provide on request the results of acceptance tests and analyses performed on raw materials.

10.6 GIDEP Alerts

See Section 12 of this document for GIDEP Alert requirements.

<table>
<tr><td colspan="3">MATERIAL USAGE AGREEMENT (MUA)</td><td colspan="6">USAGE AGREEMENT NO.:</td><td colspan="2">PAGE OF</td></tr>
<tr><td>PROJECT:</td><td colspan="2">SUBSYSTEM:</td><td colspan="6">ORIGINATOR:</td><td colspan="2">ORGANIZATION:</td></tr>
<tr><td colspan="2">DETAIL DRAWING</td><td colspan="3">NOMENCLATURE</td><td colspan="3">USING ASSEMBLY</td><td colspan="3">NOMENCLATURE</td></tr>
<tr><td colspan="2"></td><td colspan="3"></td><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td colspan="5">MATERIAL & SPECIFICATION</td><td colspan="6">MANUFACTURER & TRADE NAME</td></tr>
<tr><td colspan="5"></td><td colspan="6"></td></tr>
<tr><td rowspan="3">USAGE</td><td rowspan="3">THICKNESS</td><td rowspan="3">WEIGHT</td><td rowspan="3">EXPOSED AREA</td><td colspan="7">ENVIRONMENT</td></tr>
<tr><td colspan="2">PRESSURE</td><td colspan="3">TEMPERATURE</td><td colspan="2">MEDIA</td></tr>
<tr><td colspan="2"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="11">APPLICATION:</td></tr>
<tr><td colspan="11">RATIONALE:</td></tr>
<tr><td colspan="4">ORIGINATOR:</td><td colspan="5">PROJECT MANAGER:</td><td colspan="2">DATE:</td></tr>
</table>

FIGURE 10-1 Material Usage Agreement

FIGURE 10-2: STRESS CORROSION EVALUATION FORM

1. Part Number ____
2. Part Name ____
3. Next Assembly Number ______________________________
4. Manufacturer _______________________________________
5. Material ____
6. Heat Treatment _____________________________________
7. Size and Form ______________________________________
8. Sustained Tensile Stresses-Magnitude and Direction
    a. Process Residual ___________________________________
    b. Assembly ____
    c. Design, Static _______________________________________
9. Special Processing ___________________________________
10. Weldments
    a. Alloy Form, Temper of Parent Metal ______________________
    b. Filler Alloy, if none, indicate ____________________________
    c. Welding Process ____________________________________
    d. Weld Bead Removed - Yes ( ), No ( ) ______________________
    e. Post-Weld Thermal Treatment __________________________
    f. Post-Weld Stress Relief ______________________________
11. Environment ____
12. Protective Finish _____________________________________
13. Function of Part ______________________________________
14. Effect of Failure ______________________________________
15. Evaluation of Stress Corrosion Susceptibility _______________
16. Remarks: ____

POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT ______________________________ SYSTEM/EXPERIMENT ___________

DEVELOPER/DEVELOPER ______________________________ ADDRESS ______________________

PREPARED BY ______________________________ PHONE ______________________

DATE

GSFC MATERIALS EVALUATOR ______________________________ PHONE ________________
RECEIVED ______________________________ EVALUATED ___________

Area, cm^2	Vol., cc	Wt., gm
1 0-1	A 0-1	a 0-1
2 2-100	B 2-50	b 2-50
3 101-1000	C 51-500	c 51-500
4 >1000	D >500	d >500

ITEM NO.	MATERIAL IDENTIFICATION(2)	MIX FORMULA(3)	CURE(4)	AMOUNT CODE	EXPECTED ENVIRONMENT(5)	REASON FOR SELECTION(6)	OUTGASSING VALUES	
							TML	CVCM

NOTES

1. List all polymeric materials and composites applications utilized in the system except lubricants which should be listed on polymeric and composite materials usage list.
2. Give the name of the material, identifying number and manufacturer. Example: Epoxy, Epon 828, E. V. Roberts and Associates
3. Provide proportions and name of resin, hardener (catalyst), filler, etc. Example: 828/V140/Silflake 135 as 5/5/38 by weight
4. Provide cure cycle details. Example: 8 hrs. at room temperature + 2 hrs. at 150C
5. Provide the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. List all materials with the same environment in a group. Example: T/V : -20C/+60C, 2 weeks, 10E-5 torr, ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 mile altitude, UV, electron, proton, atomic oxygen
6. Provide any special reason why the material was selected. If for a particular property, please give the property.
   Example: Cost, availability, room temperature curing or low thermal expansion.

FIGURE 10-3 POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

INORGANIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT ______________________ SYSTEM/EXPERIMENT ______________________

DEVELOPER/DEVELOPER ______________________ ADDRESS ______________________

PREPARED BY ______________________ PHONE ______________________

DATE

GSFC MATERIALS EVALUATOR ______________________ PHONE ______________________ RECEIVED ______________________

ITEM NO.	MATERIAL IDENTIFICATION(2)	CONDITION(3)	APPLICATION(4) OR OTHER SPEC. NO.	EXPECTED ENVIRONMENT(5)	S.C.C. TABLE NO.	MUA NO.	NDE METHOD

NOTES:

1. List all inorganic materials (metals, ceramics, glasses, liquids, and metal/ceramic composites) except bearing and lubrication materials that should be listed on Form 18-59C.

2. Give materials name, identifying number manufacturer.
   Example: a. Aluminum 6061-T6
   b. Electroless nickel plate, Enplate Ni 410, Enthone, Inc.
   c. Fused silica, Corning 7940, Corning Class Works

3. Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc.
   Example: a. Heat treated to Rockwell C 60 hardness, gold electroplated, brazed.
   B. Surface coated with vapor deposited aluminum and magnesium fluoride
   c. Cold worked to full hare condition, TIG welded and electroless nickel plated.

4. Give details of where on the spacecraft the material will be used (component) and its function.
   Example: Electronics box structure in attitude control system, not hermetically sealed.

5. Give the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group.
   Example: T/V: -20C/+60C, 2 weeks, 10E-5 torr, Ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 miles altitude, UV, electron, proton, Atomic Oxygen

FIGURE 10-4 INORGANIC MATERIALS AND COMPOSITES USAGE LIST

LUBRICATION USAGE LIST

SPACECRAFT ____________________ SYSTEM/EXPERIMENT ____________________

DEVELOPED/DEVELOPER ____________________ ADDRESS ____________________

PREPARED BY ____________________ PHONE ____________________

DATE PREPARED ____________________ DATE

GSFC MATERIALS EVALUATOR ____________________ PHONE ____________________

RECEIVED ____________________ EVALUATED ____________________

ITEM NO.	COMPONENT TYPE, SIZE MATERIAL[1]	COMPONENT MANUFACTURER & MFR. IDENTIFICATION	PROPOSED LUBRICATION SYSTEM & AMT. OF LUBRICANT	TYPE & NO. OF WEAR CYCLES[2]	SPEED, TEMP., ATM. OF OPERATION[3]	TYPE OF LOADS & AMT.	OTHER DETAILS[5]

NOTES

(1) BB = ball bearing, SB = sleeve bearing, G = gear, SS = sliding surfaces, SEC = sliding electrical contacts. Give generic identification of materials used for the component, e.g., 440C steel, PTFE.

(2) CUR = continuous unidirectional rotation, CO = continuous oscillation, IR = intermittent rotation, IO = intermittent oscillation, SO = small oscillation, (<30°), LO = large oscillation (>30°), CS = continuous sliding, IS = intermittent sliding. No. of wear cycles: A(1-10^2), B(10^2-10^4), C(10^4-10^6), D(>10^6)

(3) Speed: RPM = revs./min., OPM = oscillations/min., VS = variable speed CPM = cm/min. (sliding applications). Temp. of operation, max. & min., °C Atmosphere: vacuum, air, gas, sealed or unsealed & pressure

(4) Type of loads: A = axial, R = radial, T = tangential (gear load). Give amount of load.

(5) If BB, give type and material of ball cage and number of shields and specified ball groove and ball finishes. If G, give surface treatment and hardness. If SB, give dia. of bore and width. If torque available is limited, give approx. value.

FIGURE 10-5 LUBRICATION USAGE LIST

MATERIALS PROCESS UTILIZATION LIST

SPACECRAFT________________________ SYSTEM/EXPERIMENT ________________________

DEVELOPER/DEVELOPER________________________ ADDRESS ________________________

PREPARED BY ________________________ PHONE________________________

DATE PREPARED ________________________

GSFC MATERIALS EVALUATOR ________________________ PHONE________________ DATE RECEIVED ____________

ITEM NO.	PROCESS TYPE[1]	DEVELOPER SPEC. NO.[2]	MIL., ASTM., FED. OR OTHER SPEC. NO.	DESCRIPTION OF MAT'L PROCESSED[3]	SC/EXP. APPLICATION)

NOTES

(1) Give generic name of process, e.g., anodizing (sulfuric acid).

(2) If process if proprietary, please state so.

(3) Identify the type and condition of the material subjected to the process. E.g., 6061-T6

(4) Identify the component or structure of which the materials are being processed. e.g., Antenna dish

FIGURE 10-6 MATERIALS PROCESS UTILIZATION LIST

Chapter 11.0 Contamination Control Requirements

11.1 General Requirements

Each developer shall plan and implement a contamination control program for Geospace flight hardware. Each developer shall establish the specific cleanliness requirements and delineate the approaches to meet the requirements in a Contamination Control Plan (CCP) deliverable to the Geospace Project Office for concurrence.

Contamination includes all materials of molecular and particulate nature whose presence degrades hardware performance. The source of the contaminant materials may be the hardware itself, the test facilities, and the environments to which the hardware is exposed.

11.2 Contamination Control Program

Each developer shall have a Contamination Control Program (CCP) that addresses the procedures that will be followed to control contamination. The CCP shall establish implementation and methods that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the item's lifetime. In general, all mission hardware should be compatible with the most contamination-sensitive components. The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., anti-static film materials), and purging shall be described in detail for each subsystem or component at each phase of assembly, integration, test, and launch. Each developer shall support the Geospace project in the generation of a project contamination control plan by providing support for the generation of requirements, details of instruments and I & T plans and procedures.

11.2.1 Contamination Control Verification Process

Each developer shall implement a contamination control verification process. The verification process shall be performed in order to allow the:

a. Determination of contamination sensitivity;

b. Determination of a contamination allowance;

c. Determination of a contamination budget;

11.3 Material Outgassing

All materials shall be screened in accordance with NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials. Individual material outgassing data shall be established based on each component's operating conditions. Established material outgassing data shall be verified and shall be provided to the Geospace Project Office

11.4 Thermal Vacuum Bakeout

The developer shall perform thermal vacuum bakeouts of all hardware as required to protect contamination-sensitive components. The parameters of such bakeouts (e.g., temperature, duration, outgassing requirements, and pressure) must be individualized depending on materials used, the fabrication environment, and the established contamination allowance. Thermal vacuum bakeout results shall be verified and shall be provided to the Geospace Project Office or for review.

A quartz crystal microbalance (QCM) or temperature controlled quartz crystal microbalance (TQCM) and cold finger shall be incorporated during all thermal vacuum bakeouts. These devices shall provide additional information to enable a determination of the duration and effectiveness of the thermal vacuum bakeout as well as compliance with the CCP.

Chapter 12.0 GIDEP Alerts and Problem Advisories

12.1 General Requirements

The developer shall participate in the Government/Industry Data Exchange Program (GIDEP). The developer shall transmit additional copies of documentation sent to GIDEP relevant to the Geospace hardware to the Geospace Program Systems Assurance Manager (SAM) and to the:

Alert Coordinator

Code 300/NASA Goddard Space Flight Center

Greenbelt, MD 20771

12.2 GIDEP Alert Response

Each developer shall review and disposition all Government Industry Data Exchange Program (GIDEP) Alerts for impact on flight equipment on a monthly basis. New parts procurements and parts pulled from storage shall be continuously checked for impact. Parts pulled from inventory for flight shall have the alert history checked for the period dating back to the date code marked on the parts. In addition, each developer shall review and disposition any NASA Alerts and Advisories provided to the developer by the Geospace Project. Alert applicability, impact, and corrective actions shall be documented and status provided to the Geospace Project Office on a monthly basis.

In the event of a conflict between GIDEP alerts and NASA Advisories, the NASA Advisory shall govern.

The developer shall ensure that either (1) their subs are participating in the GIDEP Program, or (2) the developer's subs are providing their parts/materials lists to the developer for GIDEP/NASA Advisory search review. All feedback shall be provided to the Geospace Program SAM and the Alert Coordinator identified above.

12.3 Documentation

Each developer shall keep parts and materials selection and usage records sufficient to determine applicability of any Government Industry Data Exchange Program (GIDEP) alerts related to materials used for Geospace Missions.

Chapter 13.0 Risk Management Requirements

13.1 General Requirements

All identified Reliability and Quality risks shall be documented and reported on in accordance with the Geospace Project's Risk Management Plan (CDRL #41). Although not all risks will be fully mitigated, all risks shall be addressed and mitigation and acceptance strategies will be agreed on in accordance with the Project Risk Management Plan and at appropriate mission reviews.

The developer/contractor shall develop and implement a Risk Management Plan to aid in performing risk assessment and risk management. Risk Management applies to all software and hardware products and processes (flight and ground) in order to identify, analyze, plan mitigation actions, track, control, and communicate risks.

The developer shall:

a. Implement a continuous program to capture, acknowledge, and document reliability and quality risks before they become problems;

b. Analyze identified risks to estimate the probability of occurrence, severity of impact, timeframe when mitigation actions are needed, and classify into sets of related risks and prioritize;

c. Develop plans to implement risk mitigation strategies and actions and assign appropriate resources;

d. Track risks being mitigated; capture risk attributes and mitigation information by collecting data; establish performance metrics; and examine trends, deviations, and anomalies;

e. Control risks by performing risk close-out, re-planning, contingency planning, or continued tracking and execution of the current plan;

f. Communicate and document (via the risk recording, reporting, and monitoring system) risk information to ensure it is conveyed between all levels of the instrument/instrument-suite;

g. Provide a "Top 10" risk list monthly from Phase B onward;

h. Report on outstanding risk items at all management and design reviews.

13.2 Risk Management Plan

The developer shall develop a Risk Management Plan for the Geospace Spacecraft, Instrument/Instrument-suite for which they are responsible. The plan shall be developed in compliance with NPR 7120.5, "NASA Program and Project Management Processes and Requirements" and the guidelines described in NPR 8000.4, "Risk Management Procedures and Guidelines". The plan shall include risks associated with hardware (technical challenges, new technology qualification, etc.), software, system safety, performance, and programmatic risks (cost and schedule). The plan shall identify the tools and techniques to be used to manage risks. The risk areas that are identified shall be addressed at peer reviews and at government reviews. The developer's plan shall address the risk areas to ensure adequate mitigation steps are in place.

13.3 Risk List

The developer shall maintain a Risk List throughout the project life cycle, along with programmatic impacts. The list should indicate which risks have the highest probability, which have the highest consequences, and which risks represent the greatest risk to mission success. The list should also identify actions being taken to address each specific risk. The Risk List shall be configuration controlled.

Risk Status shall be communicated on a regular basis to the entire project team and customers. Risk status shall be communicated to the Geospace Program Office and to the Governing Program Management Council (PMC) through Monthly Status Reviews. For each primary risk (those having both high probability and high impact/severity), the developer shall prepare and maintain the following in the risk sections of the Program/Project Plans:

a. Description of the risk, including primary causes and contributors, actions embedded in the program or project to date to reduce or control it, and information collected for tracking purposes.

b. Primary consequences should be undesired event occur.

c. Estimate of the probability of occurrence (qualitative or quantitative) together with the uncertainty of the estimate and the effectiveness of any implemented risk mitigation measures.

d. Potential additional risk mitigation measures, which shall include a comparison of the cost of risk mitigation versus the cost of occurrence multiplied by the probability of the occurrence.

e. Characterization of a primary risk as “acceptable” shall be supported by a rational (with the concurrence of the governing PMC) that all reasonable mitigation options (within cost, schedule and technical constraints) have been instituted.

Chapter 14.0 Applicable Documents List

DOCUMENT	DOCUMENT TITLE
ANSI/ASQ Q9001-2000	Model for Quality Assurance in Design, Development, Production, Installation, and Servicing
ANSI/ESD S20.20-1999	ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
ANSI/IPC-A-600	Acceptance Criteria for Printed Wiring Boards
AFSPCMAN 91-710	Range Safety User Requirements Manual
ANSI/J STD 001	Requirements for Soldered Electrical and Electronic Assemblies (not allowed for space flight hardware)
ASTM E-595	Total Mass Loss (TML) and Collected Volatile Condensable Materials (CVCM) from Outgassing in a Vacuum Environment
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components
EEE-INST-002	Instructions for EEE Parts Selection, Screening, and Qualification
GSFC PPL-21	Goddard Space Flight Center Preferred Parts List
GPD 8715.1	Goddard Space Flight Center Safety Policy
GSFC S-312-P003	Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
GSFC S-313-100	Goddard Space Flight Center Fastener Integrity Requirements
IPC-2221	Generic Standard on Printed Wiring Board Design

IPC 2222	Sectional Design Standard for Rigid Organic Printed Boards
IPC-2223	Sectional Design Standard for Flexible Printed Boards
IPC A-600	Acceptability of Printed Boards
IPC-6011	Generic Performance Specification for Printed Boards
IPC-6012	Qualification and Performance Specification for Rigid Printed Boards Flight Applications – Supplemented with: GSFC/S312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
IPC-6013	Qualification and Performance Specification for Flexible Printed Boards
ISO 17025	General Requirements for the Competence of Testing and Calibration Laboratories
KHB 1710.2D	Kennedy Space Center Safety Practices Handbook
KNPR 8715.3	KSC Safety Practices Procedural Requirements
MIL-STD-882	Systems Safety Program Requirement
MIL-STD 1629A	Procedures for Performing a Failure Mode Effects and Criticality Analysis
MSFC-HDBK-527	Material Selection List for Space Hardware Systems
MSFC-STD-3029	Design Criteria for Controlling Stress Corrosion Cracking
NASA Reference Publication (RP) 1124	Outgassing Data for Selecting Spacecraft Materials

NASA RP-1161	Evaluation of Multi-layer Printed Wiring Boards by Metallographic Techniques
NASA-STD-6001	Flammability, Odor, Off-gassing and Compatibility Requirements & Test Procedures for Materials in Environments That Support Combustion
NASA STD 8719.8	Expendable Launch Vehicle Payload Safety Review Process Standard
NASA STD 8719.9	Standard for Lifting Devices and Equipment
NASA-STD-8739.1	Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronics Assemblies Replaces NAS 5300.4(3J-1)
NASA-STD-8739.2	NASA Workmanship Standard for Surface Mount Technology (Replaces NAS 5300.4(3M)
NASA-STD-8739.3	Soldered Electrical Connections Replaces NHB 5300.4(3A-2)
NASA-STD-8739.4	Crimping Inter-connecting Cables, Harnesses, and Wiring Replaces NHB5300.4(3G)
NASA-STD-8739.5	Fiber Optics Termination Standard
NPD 8710.3B	Policy for Limiting Orbital Debris Generation
NPR 7120.5	NASA Program and Project Management Processes and Requirements
NPR 8000.4	Risk Management Procedures and Guidelines
NPR 8715.3	NASA Safety Manual
NASA-STD-8719.13A	NASA Software Safety Standard

NSS 1740.14	Guidelines and Assessment Procedures for Limiting Orbital Debris
S-311-M-70	Specification for Destructive Physical Analysis

Chapter 15.0 Acronyms

ACRONYMS

ABPL	As-Built Parts List
ABML	As-Built Materials List
ANSI	American National Standards Institute
APL	Applied Physics Laboratory
ASIC	Application Specific Integrated Circuits
ASQ	American Society for Quality
BB	Ball Bearing
BOL	Beginning of Life
CCB	Configuration Control Board
CCP	Contamination Control Plan
CDR	Critical Design Review
CDRL	Contract Deliverable Requirements List
CIL	Critical Items List
CM	Configuration Management
CR	Confirmation Review
COTS	Customer Off the Shelf
COTR	Contracting Officer’s Technical Representative
CPT	Comprehensive Performance Test
CVCM	Collected Volatile Condensable Mass
DoD	Department of Defense
DID	Data Item Description
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic, and Electromechanical
ELDR	Enhanced Low Dose Rate
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge
ESDS	Electrostatic Discharge Sensitive
ETM	Environmental Test Matrix
FMEA	Failure Modes and Effects Analysis
FOR	Flight Operations Review
FRB	Failure Review Board

FTA	Fault Tree Analysis
GEVS	General Environmental Verification Specification
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components
GFE	Government-Furnished Equipment
GIDEP	Government Industry Data Exchange Program
GOTS	Government Off the Shelf
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HQ	Headquarters
I&T	Integration and Test
ISO	International Standards Organization
IV&V	Independent Verification and Validation
KSC	Kennedy Space Center
LRR	Launch Readiness Review
LWS	Living With A Star
MAE	Materials Assurance Engineer
MAR	Mission Assurance Requirements
MCB	Materials Control Board
MCM	Multi-Chip Module
MIL	Materials Identification List
MOR	Mission Operations Review
MRB	Material Review Board
MSFC	Marshall Space Flight Center
MSPSP	Missile System Prelaunch Safety Package
MUA	Materials Usage Agreement
NAS	NASA Assurance Standard
NASA	National Aeronautics and Space Administration
NRCA	Nonconformance Reporting and Corrective Action
NSPAR	Nonstandard Parts Approval Request
NSTS	National Space Transportation System
O&SHA	Operating and Support Hazard Analysis
OSHA	Occupational Safety and Health Administration
OSSMA	Office of Systems Safety and Mission Assurance
PAPL	Project Approved Parts List
PCB	Parts Control Board
PCM	Program Management Council

PDR	Preliminary Design Review
PEM	Plastic Encapsulated Microcircuits
PER	Pre-Environmental Review
PHA	Preliminary Hazard Analysis
PMPCP	Parts, Materials and Processes Control Plan
PIL	Parts Identification List
PIND	Particle Impact Noise Detection
PPE	Project Parts Engineer
PPL	Preferred Parts List
PRA	Probabilistic Risk Assessment
PRE	Project Radiation Engineer
PSR	Pre-Ship Review
PSM	Project Safety Manager
PWB	Printed Wiring Board
QCM	Quartz Crystal Microbalance
QMS	Quality Management System
RDM	Radiation Design Margin
RE	Radiation Engineer
RFA	Request for Action
RLAT	Radiation Lot Acceptance Testing
SAM	Systems Assurance Manager
SAR	Safety Assessment Report
SB	Sleeve Bearing
SEM	Scanning Electronic Microscope
SCC	Stress Corrosion Cracking
SCD	Source Control Drawing
SCM	Software Configuration Management
SCR	System Concept Review
SOW	Statement of Work
SQMS	Software Quality Management System
SMA	Safety and Mission Assurance
SRO	Systems Review Office
SRR	Software Requirements Review
SRT	System Review Team
SSRO	System Safety and Reliability Office

STS	Space Transportation System (Shuttle)
SWG	Safety Working Group
TID	Total Ionizing Dose
TIM	Technical Interface Meetings
TML	Total Mass Loss
TRR	Test Readiness Review
V&V	Verification and Validation
VTL	Verification Tracking Log

Appendix A Data Item Descriptions

This section identifies the set of minimum documentation requirements relating to Safety and Mission Assurance (SMA) as prescribed by the GEOSPACE Mission Assurance Requirements document. Upon release of the GEOSPACE Statement of Work (SOW), for Phases A through D, this list of deliverable documentation will be incorporated into the SOW and augmented with additional deliverable requirements as prescribed in the SOW. If a GEOSPACE SOW is released for a particular Phase of the mission (for example Phase A), then the appropriate list of deliverable documentation will be incorporated into the SOW. An associated Contract Deliverable Requirements List (CDRL) will be included with the SOW to indicate the required deliverable due dates and requested formats along with approval requirements.

Note that for some deliverable documentation, instrument input to the GEOSPACE mission-level documentation is required, rather than a formal deliverable document.

The SMA documents that shall be delivered by the GEOSPACE Project as well as the instrument developers are:

CDRL #	Title
1	Quality Manual
2	Problem/Failure Reports
3	Configuration Management Plan
5	Preliminary Hazard Analysis
6	Operating and Support Hazard Analysis
7	Safety Assessment Report
9	Ground Operations Procedures
10	Safety Noncompliance Request
13	Failure Mode and Effects Analysis and Critical Items List
15	Fault Tress Analysis
16	Parts Stress Analysis
17	Worst Case Analysis
18	Reliability Assessment and Prediction
19	Trend Analysis
20	Limited Life Items List
21	Software Assurance Plan
22	Software Management Plan
24	Preliminary Design Review
25	Critical Design Review
27	Pre-Environmental Review
28	Pre-Shipment Review

31	System Performance Verification Plan
32	Requirements Verification Matrix
33	Printed Wiring Board Test Coupons
34	Parts, Materials, and Processes Control Plan
35	Program Approved Parts List
36	Parts Identification List
37	As-Built Parts List
38	Materials Identification List
39	As-Built Materials List
40	Contamination Control Plan
42	ESD Control Plan

Information to support the preparation of the APL mission-level document shall be provided for the following documentation:

CDRL #	Title
4	System Safety Program Plan
8	Missile System Prelaunch Safety Package
11	Orbital Debris Assessment
12	Safety Requirements Verification Matrix
14	Probabilistic Risk Assessment
23	System Requirements Review
26	Mission Operations Review
29	Flight Operations Review
30	Launch Readiness Review
41	Risk Management Plan

Title: Quality Manual (Phase A)	CDRL No.:1
Reference: Paragraph 1.5	
Use: Documents the developer's quality management system.	
Related Documents: ANSI/ISO/ASQ Q9001:2000, ISO 10013.	
Place/Time/Purpose of Delivery: Provide with proposal for GSFC review. Provide Quality Manual updates to GSFC Project Office for review prior to implementation, or Provide with proposal for information along with evidence of third party certification/registration of the developer's quality management system by an accredited registrar.	
Preparation Information: Prepare a Quality Manual addressing all applicable requirements of ANSI/ISO/ASQ 9001:2000. Refer to ISO 10013 for further guidelines on preparation of a quality manual. The Quality Manual shall contain: a. the title, approval page, scope and the field of application; b. table of contents; c. introductory pages about the organization concerned and the manual itself; d. the quality policy and objectives of the organization; e. the description of the organization, responsibilities and authorities, including the organization responsible for the EEE parts, materials, reliability, safety and test requirements implementation; f. a description of the elements of the quality system, developer policy regarding each element and developer implementation procedure for each clause or reference(s) to approved quality system procedures; system level procedures shall address the implementation of all requirements cited in this document. g. a definitions section, if appropriate; h. an appendix for supportive data, if appropriate. Quality Manual distribution and changes shall be implemented by a controlled process. The Quality Manual shall be maintained/updated by the developer throughout the life of the contract.	

Title: Problem Failure Reports (PFRs) (Phase C/D)	CDRL No.: 2
Reference: Paragraph 2.2.3	
Use: To report failures promptly to the Failure Review Board (FRB) for determination of cause and corrective action.	
Related Documents:	
Place/Time/Purpose of Delivery: a. Provide information to the GSFC Project Office within 24 hours of each occurrence (verbal notification); written documentation within 3 days. b. Provide to GSFC Project Office for approval immediately after developer closure.	
Preparation Information: Reporting of failures shall begin with the first power application at the start of end item acceptance testing of the major component, subsystem, or instrument level (as applicable to the hardware level for which the developer is responsible) or the first operation of a mechanical item; it shall continue through formal acceptance by the GSFC project office and the post-launch operations, commensurate with developer presence and responsibility at GSFC and launch site operations. All failures shall be documented on existing developer PFR form, which shall identify all relevant failure information. PFRs and updated information shall be submitted to GSFC by hard copy or in electronic format. PFRs submitted to the GSFC for closure include a copy of all referenced data and shall have had all corrective actions accomplished and verified.	

Title: Configuration Management Plan (Phase A)	CDRL No.: 3
Reference: Paragraph 2.4	
Use: Defines a configuration management system which conforms to the Project Configuration Management Plan and provides a means of control for all changes affecting form, fit, or function and any impact on performance, cost, or schedule..	
Related Documents: 462-PG-1410.2.1, LWS Configuration Management Procedure	
Place/Time/Purpose of Delivery:	

Preparation Information:

The contractor's Configuration Management Plan shall describe the scope, approach, methods, and procedures of the system that he will use to implement the configuration management requirements. The plan shall utilize the following product change classifications.

A change shall be classified as Class I when a new document or change is and affects one or more of the following factors:

Program baseline documentation

Technical requirements contained in the product configuration identification, including the following:

- form, fit, or function
- power
- reliability outside stated requirements
- weight, balance, moment of inertia
- interface characteristics
- hardware and process qualifications

Non-technical contractual provisions

- fee
- incentives
- cost
- schedule
- guarantees or deliveries
- Other factors
- government-furnished property (GFP)
- safety
- electromagnetic characteristics
- deliverable operational, test, or maintenance computer programs
- compatibility with support equipment

A change shall be classified as Class II when it does not fall within the definition of a Class I change.

Title: System Safety Program Plan (Phase C/D)	CDRL No.: 4

Reference:

Paragraph 3.3.1

Use:

The approved plan provides a formal basis of understanding between the GSFC SSRO and the developer on how the System Safety Program will be conducted to meet the applicable launch range safety requirements. The approved plan shall account for all contractually required tasks and responsibilities on an item-by-item basis. This plan describes in detail the tasks and activities of system safety management and engineering required to identify, evaluate, and eliminate or control hazards by reducing the associated risk to a level acceptable to Range Safety throughout the system life cycle.

Related Documents:

a. AFSPCMAN 91-710, "Range Safety User Requirements"

b NPD 8710.2, "NASA Safety & Health Program Policy"

c. NPR 8715.3, "NASA Safety Manual"

d. NASA STD 8719.8, "Expendable Launch Vehicle Payload Safety Review Process Standard"

e. NASA STD 8719.9, "Standard for Lifting Devices and Equipment".

Place/Time/Purpose of Delivery:

SSPP - The Range User shall submit a SSPP to GSFC SSRO for review and approval at SRR or first program review (whichever comes first). GSFC SSRO shall approve the SSPP before its submittal to the launch range

Product Preparation:

Provide a detailed SSPP to describe how the project will implement a safety program in compliance with launch range requirements. Integration of system/facility safety provisions into the SSPP is vital to the early implementation and ultimate success of the safety effort. The SSPP shall

a. Define the required safety documentation, applicable documents, associated schedules for completion, roles and responsibilities on the project, methodologies for the conduct of any required safety analyses, reviews, and safety package.

b. Provide for the early identification and control of hazards to personnel, facilities, support equipment, and the flight system during all stages of project development including design, fabrication, test, transportation and ground activities.

c. Ensure the program undergoes a safety review process that meets the requirements of NASA-STD-8719.8, "Expendable Launch Vehicle Payloads Safety Review Process Standard". Address compliance with the system safety requirements of range requirements.

d. Address compliance with the baseline industrial safety requirements of the institution, range safety, applicable Industry Standards to the extent practical to meet NASA and OSHA design and operational needs (i.e. NASA STD 8719.9 Std. for Lifting Devices and Equipment), and any special contractually imposed mission unique obligations (including applicable safety requirements).

e. Address the software safety effort to identify and mitigate safety-critical software products in compliance with NASA-STD-8719.13 "NASA Software Safety Standard".

Title: Safety Requirements Compliance Checklist (Phase A)	CDRL No.: 5
Reference: Paragraph 3.3.2	
Use: The checklist shall indicate for each requirement if the proposed design is compliant, non-compliant but meets intent, non-compliant (waiver required) or non-applicable.	
Related Documents: a. AFSPCMAN 91-710, “Range Safety User Requirements”	
Place/Time/Purpose of Delivery: Delivery of the Safety Requirements Compliance Checklist for instrument/subsystems shall be delivered with the SAR at PDR. Delivery of the Safety Requirements Compliance Checklist for the S/C shall be delivered with the MSPSP at mission PDR.	
Preparation Information: A compliance checklist of all design, test, analysis, and data submittal requirements shall be provided. The following items are included with a compliance checklist: 1. Criteria/requirement. 2. System. 3. Compliance. 4. Noncompliance. 5. Not applicable. 6. Resolution. 7. Reference. 8. Copies of all Range Safety approved non-compliances including waivers and equivalent levels of safety certifications	

Title: Preliminary Hazard Analysis (Phase B)	CDRL No.:6

Reference:

Paragraph 3.3.3.1

Use:

The purpose of this task is to perform and document a Preliminary Hazard Analysis (PHA) to identify safety critical areas, to provide an initial assessment of hazards, and to identify requisite hazard controls and follow-on actions.

Related Documents:

a. AFSPCMAN 91-710, Range Safety User Requirements

b. NPR 8715.3 NASA Safety Manual

c. MIL-STD-882, Systems Safety Program Requirements (provides guidance)

Place/Time/Purpose of Delivery:

The developer shall submit the PHA as a component of the SAR and/or MSPSP.

Delivery of the PHA for an <u>instrument/subsystems</u> shall be delivered with the SAR (PDR -30 days)

Delivery of the PHA for the <u>S/C</u> shall be delivered with the SDP/MSPSP (mission PDR -30 days)

Preparation Information:

Perform and document a PHA, based on the hazard assessment criteria provided in Chapter 3 of NPR 8715.3, to obtain an initial risk assessment of the system. Based on the best available data, including mishap data (if assessable) from similar systems and other lessons learned, hazards associated with the proposed design or function shall be evaluated for hazard severity, hazard probability, and operational constraint. Safety provisions and alternatives needed to eliminate hazards or reduce their associated risk to an acceptable shall be included. The PHA shall consider the following for identification and evaluation of hazards at a minimum:

a. Hazardous components.

b. Environmental constraints including the operating environments.

c. Operating, test, maintenance, built-in-tests, diagnostics, and emergency procedures.

d. Facilities, real property installed equipment, support equipment.

e. Safety related equipment, safeguards, and possible alternate approaches.

f. Safety related interface considerations among various elements of the system. This shall include consideration of the potential contribution by software to subsystem/system mishaps. Safety design criteria to control safety-critical software commands and responses shall be identified and appropriate action taken to incorporate them in the software (and related hardware) specifications.

g. Malfunctions to the system, subsystems, or software. Each malfunction shall be specified, the causing and resulting sequence of events determined, the degree of hazard determined, and appropriate specification and/or design changes developed.

Additionally, the PHA shall include a system description and a description of the methodology used to develop the analysis.

Title: Safety Assessment Report (SAR) (Phase C/D)	CDRL No.: 7
Reference: Paragraph 3.4	

Use:

The Safety Assessment Report (SAR) is used to document a comprehensive evaluation of the mishap risk being assumed prior to the testing or operation of an instrument. The SAR will be provided to the spacecraft contractor as an input to their preparation of the Missile System Prelaunch Safety Package (MSPSP), which is one of the media through which missile system prelaunch safety approval is obtained.

Related Documents:

a. AFSPCMAN 91-710, "Range Safety User Requirements"

Place/Time/Purpose of Delivery:

Delivery of the Preliminary SAR shall be delivered at the instrument/subsystem PDR.

Delivery of the Intermediate SAR shall be delivered at the instrument/subsystem CDR – 30 days.

Delivery of the Final SAR shall be delivered at Ship – 90 days

GSFC SSRO will approve all deliveries/versions.

Preparation Information:

The Safety Assessment Report will identify all safety features of the hardware, software, and system design as well as procedural, hardware, and software related hazards that may be present in the instrument or subsystem. This includes specific procedural controls and precautions that should be followed. The safety assessment will summarize the following information:

1. The safety criteria and methodology used to classify and rank hazards plus any assumptions upon which the criteria or methodologies were based or derived including the definition of acceptable risk as specified by Range Safety
2. The results of hazard analyses (including software) and tests used to identify hazards in the system including:
    a. Those hazards that still have a residual risk and the actions that have been taken to reduce the associated risk to a level contractually specified as acceptable
    b. Results of tests conducted to validate safety criteria, requirements, and analyses
3. Hazard reports documenting the results of the safety program efforts to include a list of all significant hazards along with specific safety recommendations or precautions required to ensure safety of personnel, property, or the environment. **NOTE:** The list shall be categorized as to whether or not the risks may be expected under normal or abnormal operating conditions.
4. Any hazardous materials generated by or used in the system
5. The conclusion, including a signed statement, that all identified hazards have been eliminated or their associated risks controlled to levels contractually specified as acceptable and that the system is ready to test or operate or proceed to the next acquisition phase
6. In order to aid the spacecraft contractor in completing an orbital debris assessment of the instrument it is necessary to identify any stored energy sources in instruments (pressure vessel, dewar, etc.) as well as any energy sources that can be passivated at end of life.
7. Recommendations applicable to hazards at the interface of Range User systems with other systems, as required

<table>
<tr><td colspan="1">Title:

Missile System Prelaunch Safety Package (MSPSP) or Safety Data Package (SDP) (Phase C/D)</td><td>CDRL No.:8</td></tr>
<tr><td colspan="2">Reference:
Paragraph 3.5</td></tr>
<tr><td colspan="2">Use:

Provide a detailed description of the payload design sufficient to support hazard analysis results, hazard analysis method, and other applicable safety related information. The developer shall include analyses identifying the ground operations hazards associated with the flight system, ground support equipment, and their interfaces. The developer shall take measures to control and/or minimize each significant identified hazard.</td></tr>
<tr><td colspan="2">Related Documents:

a. AFSPCMAN 91-710, “Range Safety User Requirements”

b. JSC 26943, Guidelines for the Preparation of Payload Flight Safety Data Packages and Hazard Reports

c. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook</td></tr>
<tr><td colspan="2">Place/Time/Purpose of Delivery:

Delivery of the Preliminary MSPSP shall be delivered at the mission PDR + 30 days.

Delivery of the Intermediate MSPSP shall be delivered at the mission CDR – 30 days.

Delivery of the Final MSPSP shall be delivered at Ship – 60 days

GSFC SSRO will approve all deliveries/versions.

NOTE: The first MSPSP delivery shall contain appropriate launch range safety requirements tailoring (if necessary).

*(See applicable launch range and launch vehicle requirements for details).</td></tr>
</table>

SAFETY DATA PACKAGE (cont)

Preparation Information:

The Safety Package shall include the following information:

1. Introduction. State, in narrative form, the purpose of the safety data package.

2. System Description. This section may be developed by referencing other program documentation such as technical manuals, System Program Plan, System Specification, etc.

   As applicable, either photos, charts, flow/functional diagrams, sketches, or schematics to support the system description, test, or operation.

3. System Operations.

a. A description or reference of the procedures for operating, testing and maintaining the system. Discuss the safety design features and controls incorporated into the system as they relate to the operating procedures.

b. A description of any special safety procedures needed to assure safe operations, test and maintenance, including emergency procedures.

c. A description of anticipated operating environments and any specific skills required for safe operation, test, maintenance, transportation or disposal.

d. A description of any special facility requirements or personal equipment to support the system.

4. Systems Safety Engineering Assessment. This section shall include:

a. A summary or reference of the safety criteria and methodology used to classify and rank hazardous conditions.

b. A description of or reference to the analyses and tests performed to identify hazardous conditions inherent in the system.

(1) A list of all hazards by subsystem or major component level that have been identified and considered from the inception of the program.

   a. A discussion of the hazards and the actions that have been taken to eliminate or control these items.

   b. A discussion of the effects of these controls on the probability of occurrence and severity level of the potential mishaps.

   c. A discussion of the residual risks that remain after the controls are applied or for which no controls could be applied.

   d. A discussion of or reference to the results of tests conducted to validate safety criteria requirements and analyses. These items shall be tracked and closed-out via a Verification Tracking Log (VTL).

   e. The results of the O&SHA shall be documented in the MSPSP

Title: Verification Tracking Log	CDRL No.: 9

Reference:

Paragraph 3.6

Use:

To provide a Hazard Control and Verification Tracking process or "closed-loop system" to assure safety compliance has been satisfied in accordance to applicable launch range safety requirements.

Related Documents:

a. AFSPCMAN 91-710, Range Safety User Requirements

Place/Time/Purpose of Delivery:

A Payload Safety Verification Tracking Log (VTL) identifying hazard controls still not verified closed shall be prepared and delivered with the final SDP / MSPSP to GSFC SSRO. Regular updates to this log shall be provided as requested until all hazard control verifications have been closed. Open VTL items must be closed with appropriate documented rationale prior to first operational use/restraint

Preparation Information:

The Hazard Log (or VTL) provides documentation that demonstrates the process of verifying the control of all hazards by test, analysis, inspection, similarity to previously qualified hardware, or any combination of these activities. All verifications that are listed on the hazard reports shall reference the tests/analyses/inspections. Results of these tests/analyses/inspections shall be available for review and submitted in accordance with the contract schedule and applicable launch site range safety requirements.

The VTL shall contain the following information in tabular format:

a. Log
b. Hazard Report #
c. Safety Verification #
d. Description (Identify procedures/analyses by number and title)
e. Constraints on Launch Site Operations
f. Independent Verification Required (i.e., mandatory inspection points)? Yes/No
g. Scheduled Completion Date
h. Completion Date
i. Method of Closure

Title: Ground Operations Procedures	CDRL No.: 10
Reference: Paragraph 3.7	
Use: All ground operations procedures to be used at GSFC facilities, other integration facilities, or the launch site shall be submitted to the GSFC Project Safety Manager for review and concurrence. Launch site ground operations procedures shall be submitted to applicable Range Safety 45 days prior to use.	
Related Documents: a. AFSPCMAN 91-710, Range Safety User Requirements b. KHB 1700.7, Space Shuttle Payload Ground Safety Handbook c. KNPR 1710.2, Kennedy Space Center Safety Practices Procedural Requirements d. 540-PG-8715.1.1 and 1.2, Mechanical Systems Safety Manual Volume I and II **Note**: Other launch vehicle and/or contractor, or commercial facility requirements as applicable.	
Place/Time/Purpose of Delivery: Launch Range Procedures: Provide preliminary 90 days prior to PSR and submit to applicable Range Safety 45 days prior to use. GSFC Procedures: Provide all GSFC in-house procedures to GSFC SSRO for review 7 days prior to first operational use. GSFC SSRO will approve all hazardous operational procedures	
Preparation Information: All hazardous operations as well as the procedures to control them shall be identified and highlighted. All launch site procedures shall comply with the applicable launch site safety regulation.	

Title: Safety Noncompliance Requests	CDRL No.:11

Reference:

Paragraph 3.8

Use:

The hardware developer shall submit to the GSFC SSRO an associated safety variance that identifies the hazard and shows the rationale for approval of a variance when a specific safety requirement cannot be met, as defined in NPR 8715.3. The request may require Range Safety concurrence for the variance to be approved.

Related Documents:

a. AFSPCMAN 91-710, "Range Safety User Requirements"

b. KHB 1710.2, Kennedy Space Center Safety Practices Handbook

c. NASA Non-Compliance Report/Corrective Action System (NCR/CAS) Web-based Online System

Place/Time/Purpose of Delivery:

As identified to the GSFC SSRO.

Preparation Information:

The noncompliance request shall include the following information resulting from a review of each waiver or deviation request.

a. A statement of the specific safety requirement and its associated source document name and paragraph number, as applicable, for which a waiver or deviation is being requested.

b. A detailed technical justification for the exception.

c. Analyses to show that the mishap potential of the proposed alternate requirement, method or process, as compared to the specified requirement.

d. A narrative assessment of the risk involved in accepting the waiver or deviation. When it is determined that there are no hazards, the basis for such determination should be provided.

e. A narrative on possible ways of reducing hazards severity and probability and existing compliance activities (if any).

f. Starting and expiration date for waiver/deviation.

Title: Orbital Debris Assessment	CDRL No.: 12
Reference: Paragraph 3.10	
Use: Ensure NASA requirements for post mission orbital debris control are met.	
Related Documents: a. NPD 8710.3, NASA Policy for Limiting Orbital Debris Generation b. NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris	
Place/Time/Purpose of Delivery: Provide preliminary assessment at mission PDR to NASA HQ and final package at CDR – 60 days. Additional information may be required after NASA HQ review of the report and should be provided as soon as possible to complete the assessment, NOTE: NASA HQ needs to provide approval prior to shipment to the launch ranges.	
Preparation Information: The assessment shall be done in accordance with NSS 1740.14, Guidelines and Assessment Procedures for Limiting Orbital Debris. The preliminary debris assessment should be conducted to identify areas where the program or project might contribute debris and to assess this contribution relative to the guidelines in so far as is feasible. Prior to CDR another debris assessment should be completed. This report should comment on changes made since the PDR report. The level of detail should be consistent with the available information of design and operations. When there are design changes after CDR that impact the potential for orbital debris generation, and update of the debris assessment report should be prepared, approved, and coordinated with the Office of System Safety and Mission Assurance. Orbital Debris Assessment Software is available for download from Johnson Space Center at URL: http://sn-callisto.jsc.nasa.gov/mitigate/das/das.html	

<table>
<tr><td>Title:
Failure Mode and Effects Analysis (FMEA) and Critical Items List (CIL)
(Phase B/D)</td><td>CDRL No.:
13</td></tr>
<tr><td colspan="2">Reference:
Paragraph 4.4.1</td></tr>
<tr><td colspan="2">Use:
The FMEA is a reliability analysis to evaluate design relative to requirements, identify single point failures, and identify hazards so as to guide preventive design actions. The CIL provides a list of critical items, which require the highest level of attention in design, fabrication, verification, and problem correction during the development, handling, and mission use of the system.</td></tr>
<tr><td colspan="2">Related Documents
a. Flight Assurance Procedure, FAP P-302-720, Performing a Failure Mode and Effects Analysis.
b. CR 5320.9, Payload and Experiment Failure Mode Effects Analysis and Critical Items List Ground Rules.
c. MIL-STD-1629, Procedures for Performing an FMECA.</td></tr>
<tr><td colspan="2">Place/Time/Purpose of Delivery:
a. Preliminary 30 days before PDR for GSFC review.
b. Final 30 days before CDR for GSFC review.
c. Updates as required including changes for GSFC review.</td></tr>
<tr><td colspan="2">Preparation Information:
The FMEA report shall document the reliability analysis including approach, methodologies, results, conclusions, and recommendations. The report shall include objectives, level of the analysis, ground rules, functional description, functional block diagrams, reliability block diagrams, bounds of equipment analyzed, reference to data sources used, identification of problem areas, single-point failures, recommended corrective action, and work sheets as appropriate for the specific analysis being performed.

The Critical Items List shall include item identification, cross-reference to FMEA line items, and retention rationale. Appropriate retention rationale may include design features, historical performance, acceptance testing, manufacturing product assurance, elimination of undesirable failure modes, and failure detection methods.</td></tr>
</table>

Title: Probabilistic Risk Assessment (PRA) (Phase A)	CDRL No.: 14
Reference: Paragraph 4.2, 4.2.1.2	
Use: PRAs provide a structured, disciplined approach to analyzing system risk to support management decisions to: ensure mission success; improve safety in design, operation, maintenance and upgrade; improve performance; and reduce design, operation and maintenance costs.	
Related Documents N/A.	
Place/Time/Purpose of Delivery: a. PRA Planning Document 6 months before PDR for review and approval. b. Preliminary PRA 30 days before PDR for review. c. Final PRA 30 days before CDR for approval. d. Updates as changes are made; between CDR and delivery, for approval.	
Preparation Information: As part of the PRA, a PRA Planning Document shall be prepared that identifies what types of analyses are to be performed for each scenario, and what modeling tools and techniques are to be used (e.g., Master Logic Diagrams (MLD), Failure Mode and Effects Analysis (FMEA), Fault Tree Analyses (FTA), Event Tree Analyses (ETA), Event Sequence Diagrams. The PRA shall include: a. A definition of the objective and scope of the PRA, and development of end-states-of-interest to the decision-maker, b. Definition of the mission phases and success criteria, c. Initiating event categories, d. Top level scenarios, e. Initiating and pivotal event models (e.g., fault trees and phenomenological event models), f. Data development for probability calculations, g. An integrated model and quantification to obtain risk estimates, h. An assessment of uncertainties, i. Summary of results and conclusions, including a ranking of the lead contributors to risk.	

Title: Fault Tree Analysis (FTA) (Phase B/D)	CDRL No.: 15
Reference: Paragraph 4.2.1.1	
Use: A fault tree is an analytical technique, whereby an undesired state of the system is specified, and the system is then analyzed in the context of its environment and operation to find all credible ways in which the undesired event can occur. The analysis provides a methodical approach to understanding the system, its operation, and the environment it will operate in. Through this understanding, informed decisions regarding system design and operation can be made.	
Related Documents a. NUREG-0492, Fault Tree Handbook	
Place/Time/Purpose of Delivery: a. Preliminary 30 days before PDR for GSFC review. b. Final 30 days before CDR for GSFC review. a. Updates as required including changes for GSFC review.	
Preparation Information: The Fault Tree Analysis Report shall contain: a. Ground rules for the analysis, including definitions of the undesirable end states analyzed, b. References to documents and data used, c. The fault tree diagrams, d. Statement of the results and conclusions.	

<table>
<tr><td>Title:
Parts Stress Analysis (Phase B/D)</td><td>CDRL No.:
16</td></tr>
<tr><td colspan="2">Reference:
Paragraph 4.2.1.3</td></tr>
<tr><td colspan="2">Use:
Provides EEE parts stress analyses for evaluating circuit design and conformance with derating guidelines, and demonstrates that environmental operational stresses on parts comply with project derating requirements.</td></tr>
<tr><td colspan="2">Related Documents
NASA Parts Selection List</td></tr>
<tr><td colspan="2">Place/Time/Purpose of Delivery:
a. Final 45 days before GSFC CDR for GSFC review
b. Updates to include changes as required for GSFC review</td></tr>
<tr><td colspan="2">Preparation Information:
The stress analysis report shall contain:
a. Ground rules for the analysis,
b. References to documents and data used,
c. Statement of the results and conclusions,
d. Analysis worksheets. The worksheets at a minimum shall include:
– Part identification (traceable to circuit diagrams),
– Environmental conditions assumed (consider all expected environments),
– Rated stress,
– Applied stress (consider all significant operating parameter stresses at the extremes of anticipated environments),
– Ratio of applied-to-rated stress.</td></tr>
</table>

Title: Worst Case Analysis (Phase C/D)	CDRL No.: 17
Reference: Paragraph 4.2.1.4	
Use: To demonstrate the adequacy of margin in the design of electronic and electrical circuits, optics, and electromechanical and mechanical items.	
Related Documents a. NPD 8720.1, NASA Reliability and Maintainability (R&M) Program Policy. b. NASA-STD-8729.1, Planning, Developing and Managing an Effective R&M Program.	
Place/Time/Purpose of Delivery: a. Available 30 days prior to component CDR b. Updates with design changes.	
Preparation Information: These analyses shall address the worst case conditions for the analysis performed on each component. Each analysis shall encompass the mission life and consider the critical parameters set at maximum and minimum limits and include the effect of environmental stresses on the operational parameters being evaluated.	

Title:

Reliability Assessments and Predictions (Phase B/D)

CDRL No.:

18

Reference:

Paragraph 4.2.1.5

Use:

Reliability analysis to assist in evaluating alternative designs and to identify potential mission limiting elements that may require special attention.

Related Documents:

MIL-STD-756, Reliability Modeling and Prediction

MIL-HDBK-217, Reliability Prediction of Electronic Equipment

RADC-TR-85-229, Reliability Prediction for Spacecraft

Place/Time/Purpose of Delivery:

a. Available at PDR and CDR for information.

b. Available on request

Preparation Information:

The assessment report shall document the methodology and results of comparative reliability assessments including mathematical models, reliability block diagrams, failure rates, failure definitions, degraded operating modes, trade-offs, assumptions, and any other pertinent information used in the assessment process.

Format of the report is not critical, but it should incorporate good engineering practices and clearly show how reliability was considered as a discriminator in the design process.

Title: Trend Analysis (Phase C/D)	CDRL No.: 19
Reference: Paragraph 4.3.1	
Use: To monitor parameters on components and subsystems throughout the normal test program that relate to performance stability (any deviations from the nominal that could indicate trends). Operational personnel continue monitoring trends through mission duration.	
Related Documents: None	
Place/Time/Purpose of Delivery: a. List of parameters to be monitored at time of CDR for information. b. Trend Analysis Reports at time of PER and FRR for information.	
Preparation Information: The system for selecting parameters related to performance stability, recording any changes from the nominal, analyzing trends, and coordinating results with design and operational personnel shall be documented. List of parameters to be monitored, updates to the list and trend reports shall be prepared. In addition a log shall be kept for each black box or unit (e.g. tape recorder) of the accumulated operating time. The log shall include the following minimum information: a. Identification b. Serial Number c. Total operating time since assembly of unit d. Total operating time at each parameter observation e. Total additional operating time projected for the unit prior to launch.	

<table>
<tr><td>Title:
Limited-Life Items List (Phase B/D)</td><td>CDRL No.:
20</td></tr>
<tr><td colspan="2">Reference:
Paragraph 4.4</td></tr>
<tr><td colspan="2">Use:
Defines and tracks the selection, use and wear of limited-life items, and the impact on mission operations</td></tr>
<tr><td colspan="2">Related Documents
None</td></tr>
<tr><td colspan="2">Place/Time/Purpose of Delivery:
a. Preliminary 30 days before PDR for review.
b. Final 30 days before CDR for approval.
c. Updates as changes are made; between CDR and delivery, for approval.</td></tr>
<tr><td colspan="2">Preparation Information:
List life-limited items and their impact on mission parameters. Define expected life, required life, duty cycles, and rationale for selecting and using the items. Include selected structures, thermal control surfaces, solar arrays, and electromechanical mechanisms. Atomic oxygen, solar radiation, shelf-life, extreme temperatures, thermal cycling, wear and fatigue are used to identify limited-life thermal control surfaces and structural items. When aging, wear, fatigue and lubricant degradation limit their life, include batteries, compressors, seals, bearings, valves, tape recorders, momentum wheels, gyros, actuators and scan devices.</td></tr>
</table>

Title: Software Assurance Plan (Phase A)	CDRL No.: 21
Reference: Paragraph 5.2	
Use: The Software Assurance Plan documents the Software Assurance roles and responsibilities, surveillance activities, supplier controls, records collection, maintenance and retention, training and risk management.	
Related Documents IEEE Standard 730, Software Quality Assurance Plans	
Place/Time/Purpose of Delivery: a. Initial draft due upon project inception. b. Final due no later than requirements phase. c. Updated periodically throughout the lifecycle, if necessary.	
Preparation Information: The Software Assurance Plan (SAP) shall follow the format as specified in the IEEE Standard 730: a. Purpose; Reference documents and definitions; b. Management; c. Documentation; d. Standards, practices, conventions, and metrics; e. Software Reviews; f. Test; g. Problem Reporting and Corrective Action; h. Tools, techniques, and methodologies; i. Media control; j. Supplier control; k. Records, collection, maintenance, and retention; l. Training; m. Risk Management; n. SAP Change procedure and history.	

Title: Software Management Plan (Phase A)	CDRL No.: 22
Reference: Paragraphs 5.2	
Use: This data item provides an outline for the Software Management Plan. The Software Management Plan documents the software development processes and procedures, software tools, resources, and deliverables throughout the development life cycle.	
Related Documents: IEEE Standard 1058-1998	
Place/Time/Purpose of Delivery: a. Initial draft due upon project inception. b. Final due no later than requirements phase. c. Updated periodically throughout the lifecycle, as necessary.	
Preparation Information: The Software Management Plan shall include/address: a. Introduction – Purpose, scope, definitions and references; b. Project Organization and Responsibilities - Resources and Schedules; c. Software Development Overview; d. Software Development Activities by life cycle: 1) Development and test environment; 2) Tools, techniques, and methodologies; 3) Software standards and development processes; e. Software Configuration Management; f. Software Assurance; g. Software Testing; h. Software Reviews; i. Risk Management; j. Software Metrics; k. Delivery and Operational Transition; l. Software Maintenance; m. Software Deliverables; n. Training.	

Title: System Requirements Review (SRR) (Phase A)	CDRL No.: 23
Reference: Paragraph 6.2	
Use: To evaluate compliance with success criteria delineated in the SRO review guidelines.	
Related Documents None	
Place/Time/Purpose of Delivery: Deliver to IIRT (predetermined number of days) prior to commencement of the review for information.	
Preparation Information: See the SRO review guidelines.	

<table>
<tr><td>Title:
Preliminary Design Review (PDR) (Phase B)</td><td>CDRL No.:
24</td></tr>
<tr><td colspan="2">Reference:

Paragraph 6.2</td></tr>
<tr><td colspan="2">Use:
To evaluate compliance with the review criteria delineated in the SRO review guidelines</td></tr>
<tr><td colspan="2">Related Documents
None</td></tr>
<tr><td colspan="2">Place/Time/Purpose of Delivery:
Deliver to IIRT (predetermined number of days) prior to commencement of the review for information</td></tr>
<tr><td colspan="2">Preparation Information:
• See the SRO review guidelines</td></tr>
</table>

Title: Critical Design Review (CDR) (Phase C/D)	CDRL No.: 25
Reference: Paragraph 6.3	
Use: To evaluate compliance with the review criteria delineated in the SRO review guidelines	
Related Documents None	
Place/Time/Purpose of Delivery: Deliver to IIRT (predetermined number of days) prior to commencement of the review for information	
Preparation Information: See the SRO review guidelines	

Title: Mission Operations Review (MOR) (Phase C/D)	CDRL No.: 26
Reference: MAR Paragraph 6.3	
Use: To evaluate compliance with the review criteria delineated in the SRO review guidelines	
Related Documents None	
Place/Time/Purpose of Delivery: Deliver to IIRT (predetermined number of days) prior to commencement of the review for information	
Preparation Information: • See the SRO review guidelines	

Title: Pre-Environmental Review (PER) (Phase C/D)	CDRL No.: 27
Reference: Paragraph 8.2.1e	
Use: To evaluate compliance with the review criteria delineated in the SRO review guidelines	
Related Documents: None	
Place/Time/Purpose of Delivery: Deliver to IIRT (predetermined number of days) prior to commencement of the review for information	
Preparation Information: • See the SRO review guidelines	

Title: Pre-Shipment Review (PSR) (Phase C/D)	CDRL No.: 28
Reference: MAR Paragraph 6.3	
Use: To evaluate compliance with the review criteria delineated in the SRO review guidelines	
Related Documents None	
Place/Time/Purpose of Delivery: Deliver to IIRT (predetermined number of days) prior to commencement of the review for information	
Preparation Information: See the SRO review guidelines	

Title: Flight Operations Review (FOR) (Phase C/D)	CDRL No.: 29
Reference: Paragraph 6.3	
Use: To evaluate compliance with the review criteria delineated in the SRO review guidelines	
Related Documents None	
Place/Time/Purpose of Delivery: Deliver to IIRT (predetermined number of days) prior to commencement of the review for information	
Preparation Information: See the SRO review guidelines	

Title: Launch Readiness Review (LRR) (Phase C/D)	CDRL No.: 30
Reference: Paragraph 6.3	
Use: To evaluate compliance with the review criteria delineated in the SRO review guidelines	
Related Documents None	
Place/Time/Purpose of Delivery: Deliver to IIRT (predetermined number of days) prior to commencement of the review for information	
Preparation Information: See the SRO review guidelines	

Title: System Performance Verification Plan (Phase A/D)	CDRL No.: 31
Reference: Paragraph 7.1	
Use: Provides the overall approach for accomplishing the verification program. Defines the specific tests, analyses, calibrations, alignments, etc. that will demonstrate that the hardware complies with the mission requirements	
Related Documents None	
Place/Time/Purpose of Delivery: Preliminary with proposal for GSFC review. Final at CDR for GSFC approval. Updates as required.	
Preparation Information: Describes the approach (test, analysis, etc.) that will be utilized to verify that the hardware/software complies with mission requirements. If verification relies on tests or analyses at other level of assemblies, describe the relationships. A section of the plan shall be a "System Performance Verification Matrix" summarizing the flow-down of system specification requirements that stipulates how each requirement will be verified, and summarizes compliance/non-compliance with requirements. It shall show each specification requirement, the reference source (to the specific paragraph or line item), the method of compliance, applicable procedure references, report reference numbers, etc. The System Performance Verification Matrix may be made a separate document. The System Performance Verification Plan shall include a section describing the environmental verification program. This shall include level of assembly, configuration of item, objectives, facilities, instrumentation, safety considerations, contamination control, test phases and profiles, appropriate functional operations, personnel responsibilities, and requirements for procedures and reports. For each analysis activity, include objectives, a description of the mathematical model, assumptions on which the model will be based, required output, criteria for assessing the acceptability of the results, interaction with related test activity, and requirements for reports. Provide for an operational methodology for controlling, documenting, and approving activities not part of an approved procedure. Plan controls that prevent accidents that could damage or contaminate hardware or facilities, or cause personal injury. The controls shall include real-time decision-making mechanisms for continuation or suspension of testing after malfunction, and a method for determining retest requirements, including the assessment of the validity of previous tests. Include a test matrix that summarizes all tests to be performed on each component, each subsystem, and the payload. Include tests on engineering models performed to satisfy qualification requirements. Define pass/fail criteria. The Environmental Verification. The Environmental Test Plan section shall include a Environmental Test Matrix that summarizes all environmental tests that will be performed showing the test and the level of assembly. Tests on development/engineering models performed to satisfy qualification requirements shall be included in this matrix.	

<table>
<tr><td>Title:
System Performance Verification Plan (cont.)</td><td>CDRL No.:
31</td></tr>
<tr><td colspan="2">Reference:
Paragraph 7.1</td></tr>
<tr><td colspan="2">Use:
Provides the overall approach for accomplishing the verification program. Defines the specific tests, analyses, calibrations, alignments, etc., that will demonstrate that the hardware complies with the mission requirements</td></tr>
<tr><td colspan="2">Related Documents
None</td></tr>
<tr><td colspan="2">Place/Time/Purpose of Delivery:
Preliminary with proposal for GSFC review.
Final at CDR for GSFC approval.
Updates as required.</td></tr>
<tr><td colspan="2">Preparation Information: (cont.)
The Environmental Verification Plan may be made a separate document rather than be a section of the System Performance Verification Plan. As an adjunct to the environmental verification program, an Environmental Test Matrix Summarizing all tests performed and showing the test and the level of assembly will be maintained.
The System Performance Verification Plan shall include an Environmental Verification Specification section that stipulates the specific environmental parameters used in each test or analysis required by the verification plan. Contains the specific test and analytical parameters associated with each of the tests and analyses required by the Verification Plan. Payload peculiarities and interactions with the launch vehicle shall be considered when defining quantitative environmental parameters under which the hardware elements must meet their performance requirements.</td></tr>
</table>

Title: Requirements Verification Matrix (Phase C/D)	CDRL No.: 32
Reference: Paragraph 7.2	
Use: Shows flow-down of all requirements and methods of verification	
Related Documents None	
Place/Time/Purpose of Delivery: 30 days prior to test for GSFC approval.	

Preparation Information:

The matrix shall provide the following information:

- Systems Performance Validation Plan flow-down;
- Basis for verification method (test, analysis, similarity, heritage, etc.);
- Dates accomplished with name and signature of person performing the action;
- Dates verified with name and signature of person verifying performance;
- Definition of specific environments for each requirement;
- Tracking of requirements verified against those planned;
- Detailed supporting documentation of compliance with each requirement.

Title: Printed Wiring Board (PWB) Test Coupons (Phase C/D)	CDRL No.: 33
Reference: Paragraph 8.3.3	
Use: Validate printed wiring boards procured for space flight and mission critical ground applications are fabricated in accordance with applicable workmanship standards.	
Related Documents: IPC-6011, Generic Performance Specifications for Printed Boards (must use Class 3 Requirements) IPC-6012, Qualification and Performance Specification for Rigid Printed Boards (must use Class 3 Requirements) IPC-6013, Qualification and Performance Specification for Flexible Printed Boards (must use Class 3 Requirements) IPC A-600, Guidelines for Acceptability of Printed Boards (must use Class 3 Requirements)	
Place/Time/Purpose of Delivery: Prior to population of flight PWBs. Applies individually to each procured lot of boards.	
Preparation Information: Prior to population of printed wiring boards: • Contact GSFC Materials Engineering Branch (MEB), Code 541. • Submit test coupons for destructive physical analysis (DPA) per Code 541 procedures. • Do not release PWBs for population until notification by MEB that test coupons passed DPA.	

Title: Parts, Materials and Processes Control Plan (Phase A/D)	CDRL No.: 34

Reference:

Paragraph 9.1

Use:

Description of developer's approach and methodology for implementing PMPCP, including flow-down of applicable PMPCP requirements to sub-developers.

Related Documents

Place/Time/Purpose of Delivery:

The PMPCP shall be developed and delivered as part of the proposal for GSFC review

Preparation Information:

The PMPCP shall be prepared and shall address all PMP program requirements. The PMPCP shall contain, as a minimum, detailed discussions of the following:

a. The developer's plan or approach for conforming to PMP requirements.

b. The developer's PMP control organization, identifying key individuals and specific responsibilities.

c. Detailed Parts Control Board and Materials and Processes Control Board procedures, to include membership, designation of Chairperson, responsibilities, review and approval procedures, meeting schedules and method of notification, meeting minutes, etc.

d. PMP tracking methods and approach, including tools to be used such as databases, reports, NASA Parts Selection List (NPSL), etc. Describe system for identifying and tracking PMP approval status.

e. PMP procurement, processing and testing methodology and strategies. Identify internal operating procedures to be used for incoming inspections, screening, qualification testing, derating, testing of PMP pulled from stores, Destructive Physical Analysis, radiation assessments, etc.

f. PMP vendor surveillance and audit plan

g. Flow down of PMPCP requirements to sub-developers

Title: Program Approved Parts List (Phase B)	CDRL No.:35
Reference: Paragraph 9.2	
Use: Listing of all PMP intended for use in space flight hardware	
Related Documents: Parts, Materials and Processes Control Program Plan	
Place/Time/Purpose of Delivery: The PMPL shall be submitted to the PMPCB, ten days prior to the first PCB and MCB meetings	

Preparation Information:

The PMPL shall be prepared prior to the first PMPCB meeting. The PMPL shall be compiled by instrument, instrument component, or spacecraft component, and shall include the following information, as a minimum:

a. PMP name

b. PMP number

c. Manufacturer

d. Manufacturer’s generic PMP number

e. Procurement specification

Any format may be used provided the required information is included. All submissions to GSFC will include a paper copy and a computer readable form.

Updates to PMPL shall identify changes from the previous submission.

Title: Parts Identification List (Phase C/D)	CDRL No.:36
Reference: Paragraph 9.6.1	
Use:	
Related Documents Parts, Materials and Processes Control Program Plan	
Place/Time/Purpose of Delivery: 45 days Prior to PDR	
Preparation Information: The PIL shall list all parts proposed for use in flight hardware. The PIL is prepared from design team inputs or subcontractor inputs, to be used for presenting candidate parts to the PMCB. The PIL shall include as a minimum the following information: Item number Procurement Part number Spacecraft Name Instrument Name Generic Part Number Description, Package: Case Style and Number of pins Manufacturer Cage Code Distributor Additional Testing Required Quantity needed Quantity Procured Radiation Hardness Evaluation: TID, Krads Radiation Hardness Evaluation: SEL, MeV Radiation Hardness Evaluation: SEU, MeV Radiation Hardness Evaluation: Displacement Damage Radition Data Source: TID Radiation Data Source: SEE Long Lead items Conditional Approval PCB Comments Approval Date	

Title: As-Built Parts List (Phase C/D)	CDRL No.:37
Reference: Paragraph 9.6.3	
Use:	
Related Documents: Parts, Materials and Processes Control Program Plan	
Place/Time/Purpose of Delivery: Final: 60 days after each Model Delivery	
Preparation Information: The ABPL is generally a final compilation of all parts as installed in flight equipment, with additional "as-installed" part information such as manufacturer name, CAGE code, Lot-Date Code, part serial number (if applicable). Provisions shall be in place to find quantity used and provide traceability to box or board location through build paperwork. The manufacturer's plant specific CAGE code is preferred, but if unknown, the supplier's general cage code is sufficient.	

Title: Materials Identification List (Phase C/D)	CDRL No.38
Reference: Paragraph 10.2.1	
Use: For usage evaluation and approval of non-compliant materials and lubrication usage	
Related Documents Parts, Materials and Processes Control Program Plan	
Place/Time/Purpose of Delivery: Preliminary Materials List 30 days before PDR Final Materials List 30 days before CDR	
Preparation Information: The MILs shall include information for Polymeric Materials and Composites Usage, Inorganic Materials and Composites Usage, Lubrication Usage, and Material Process Utilization. Reference lists are provided in this document as a guide for all developer's (Figures 10-3 through 10-6). The MIL can be submitted as one list as long as it contains all the appropriate information referenced in the attached figures. These lists shall be reviewed and approved by the Geospace Project Materials Assurance Engineer (MAE).	

Title: As-Built Materials List (Phase C/D)	CDRL No.: 39

Reference:

Paragraph 10.2.1

Use:

Details the actual configuration of the delivered article(s). Provides data on as-built material usage.

Related Documents

Parts, Materials and Processes Control Program Plan

Place/Time/Purpose of Delivery:

Hardware delivery

Preparation Information:

The As-Built Materials and Lubrication List shall provide a final compilation of all materials and lubrication used in flight equipment, with additional information such as manufacturer name, CAGE code, quantity required and box or board location. The manufacturer's plant specific CAGE code is preferred, but if unknown, the supplier's general cage code is sufficient

The As-built Materials and Lubrication List **shall** be in accordance with figures shown in Chapter 10 of the GEOSPACE Mission Assurance Requirements, 462-RQMT-0001.

A separate As-built Materials and Lubrication List shall be submitted for each assembly.

Title: Contamination Control Plan (Phase B)	CDRL No.: 40

Reference:

Paragraph 11.1

Use:

To establish contamination allowances and methods for controlling contamination

Related Documents:

None.

Place/Time/Purpose of Delivery:

Provide to the Project Office 30 days before PDR for GSFC review and 30 days before the CDR for approval.

Preparation Information:

Data on material properties, on design features, on test data, on system tolerance of degraded performance, on methods to prevent degradation shall be provided to permit independent evaluation of contamination hazards. The items should be included in the plan for delivery:

1. Materials
   a. Outgassing as a function of temperature and time.
   b. Nature of outgassing chemistry.
   c. Areas, weight, location, view factors of critical surfaces.
2. Venting: size, location and relation to external surfaces.
3. Thermal vacuum test contamination monitoring plan including vacuum test data, QCM location and temperature, pressure data, system temperature profile and shroud temperature.
4. On orbit spacecraft and instrument performance as affected by contamination deposits.
   a. Contamination effect monitor.
   b. Methods to prevent and recover from contamination in orbit.
   c. How to evaluate in orbit degradation.
   d. Photopolymerization of outgassing products on critical surfaces.
   e. Space debris risks and protection.
   f. Atomic oxygen erosion and re-deposition.
5. Analysis of contamination impact on the satellite on orbit performance.
6. In orbit contamination impact from other sources such as STS, space station, and adjacent instruments.

Title: Risk Management Plan (Phase A)	CDRL No.:41
Reference: Paragraph 13.2	
Use: The purpose of the Risk Management Plan is to define the Continuous Risk Management (CRM) process by which the developer identifies, evaluates, and minimizes the risks associated with program, project, and/or mission goals.	
Related Documents: GPG 7120.4, Risk Management NPG 8000.4, Risk Management Procedures and Guidelines	
Place/Time/Purpose of Delivery: Provide to the Project Office 30 days before PDR for GSFC review and 30 days before the CDR for approval.	
Preparation Information: 7. The Risk Management Plan (RMP) shall be a configuration-controlled document. The RMP shall include: a. Introduction. Specify the project risk objectives and policy toward risk. Explain the purpose, scope, assumptions, constraints, key ground rules, and policy pertaining to the project CRM process. b. Overview of Process. Provide an overview of the CRM process and information flow; describe how the CRM process integrates and relates to other project management and system engineering activities. Include general risk mitigation strategies to be employed throughout project life cycle. c. Organization. Show the organization, roles, and responsibilities of program, project, customer, and supplier key personnel with regard to CRM. Document how team members will be trained in the application of CRM methodology. d. Process Details. Provide the CRM process details and related procedures, methods, tools, and metrics. Include here, or in an appendix, the specific methodologies to be used for activities of continuous risk management: identify, analyze, plan, track, control, communicate and document. Include the process to be used for continual assessment of the project Risk Profile. Describe how risk information will be communicated both internally to the project staff and throughout the NASA management chain. e. Documentation of Risks. Specify the format and data elements that will comprise the project Risk List (and/or Risk database), how configuration control will be applied, and how the list will be used and updated. Tell how team members will be able to access the current list at any time. Include in the RMP the initial set of identified risks and the action plan (for research, acceptance, tracking, or mitigation) for each risk. f. Appendix. Material that is too detailed or sensitive to be placed in the main body of text may be placed in an appendix or included as reference. Include the appropriate reference in the main body of the text. Appendices may be bound separately, but are considered to be part of the document and shall be placed under configuration control as such. Include an alphabetized list of the definitions for abbreviations and acronyms used in this document. Include an alphabetized list of definitions for special terms used in the document, i.e., terms used in a sense that differs from or is more specific than the common usage for such terms.	

Title: Electrostatic Control Plan (Phase C/D)	CDRL No.: 42
Reference: Paragraph 8.8	
Use: To establish methods for controlling electrostatic discharge	
Related Documents: ANSI/ESD S20.20-1999	
Place/Time/Purpose of Delivery: Provide to the Project Office 30 days before PDR for GSFC review and 30 days before the CDR for approval.	
Preparation Information: At a minimum, the ESD Control Program shall address: training, protected work area procedures and verification schedules, personal grounding devices, handling of Electrostatic Discharge Sensitive items packaging, facility maintenance, storage and shipping	